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The Chemical Age

VOL LXV 4 AUGUST 1951 No 1673

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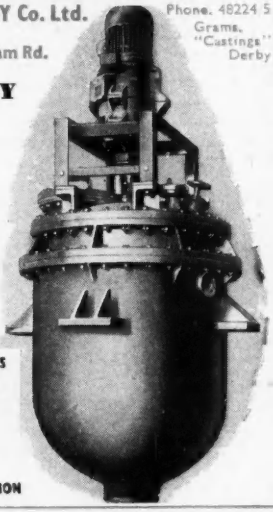

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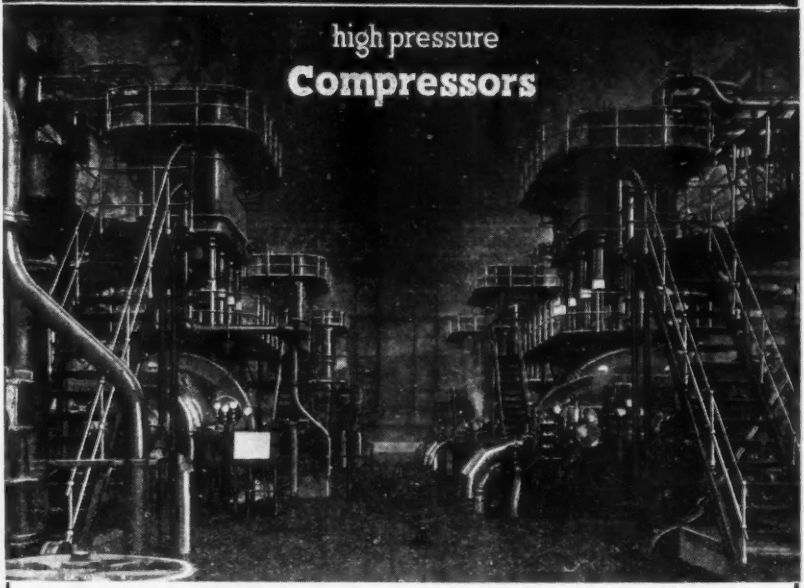

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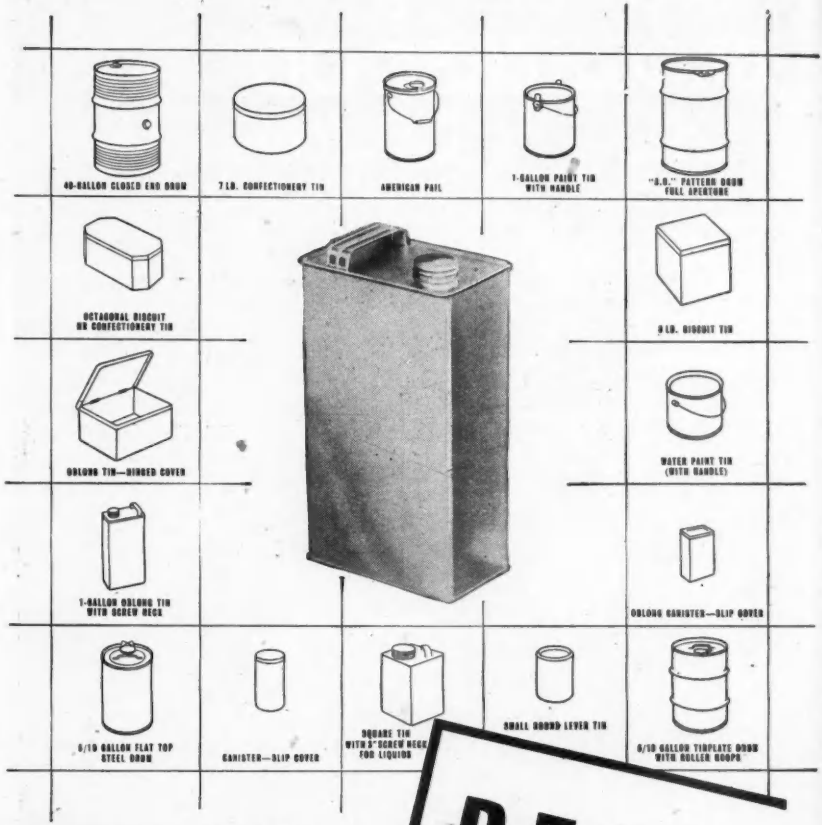
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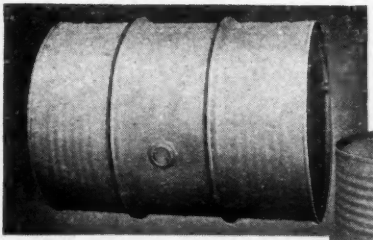

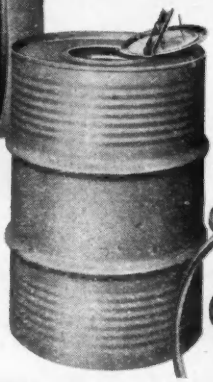

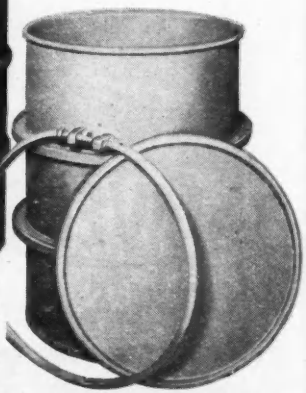

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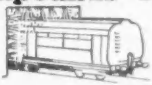
For the formulation of compounds for washing cars **and trains**  **and even buildings** **for the preparation of glass-cleaning detergents for dairies, hotels etc.** **for cleaning, treating or pickling metal in alkaline or acid solutions** **for wetting textile fibres** **washing fruit and vegetables** **for agricultural sprays** **and insecticides, for packing as a synthetic detergent as such** **or for compounding with great ease into detergent and scouring powders** **the ideal base for every type of detergent is ....**

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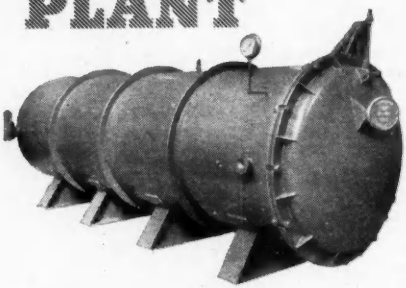

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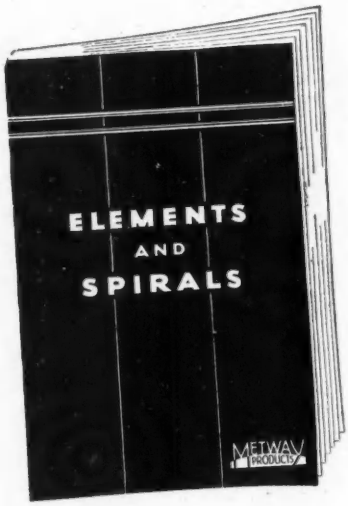

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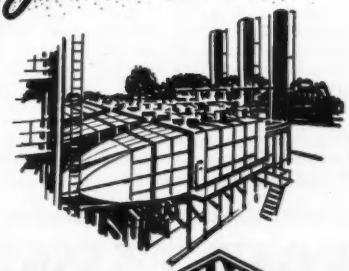

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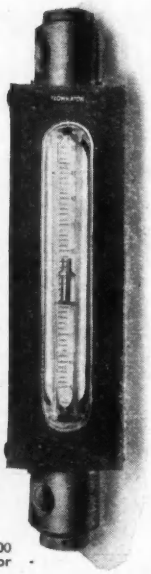

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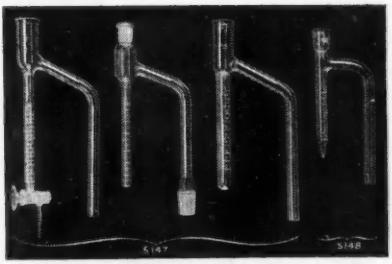

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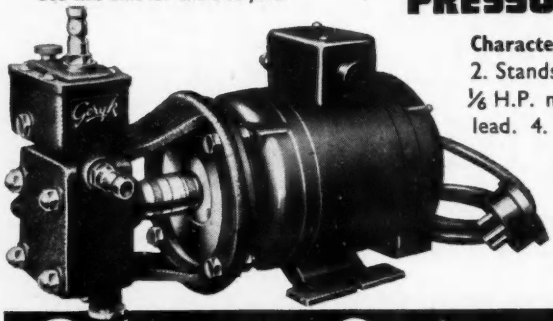

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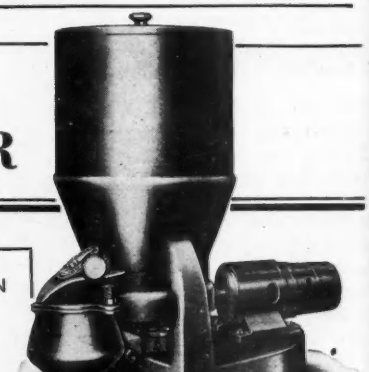

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Volume LXV **4 August 1951** **Number 1673**

Tighter & Colder

THE Chancellor of the Exchequer's new proposals for curbing inflation give the screw of our tightening industrial economy not merely one more turn, but several turns. The question many will ask is whether this screw will not eventually become a coffin nail. Government spokesmen have frequently stated that one of the major causes of current inflationary pressure—indeed, the major cause—is the steady rise of prices in world markets. In short, a great part of the price-rising tendency is outside our own control. Mr. Gaitskell's remedy, therefore, is to tighten capital advances and availability and to place a ceiling upon dividend distribution. The closer control upon capital borrowing will make it less easy for companies to obtain the funds with which to buy increasingly costly raw materials. The restriction upon dividend payments will discourage expansion in production, particularly since further advances in productive capacity now require more capital both for plant and raw materials. At the very time when vigour and enterprise are needed at home the springs of vigour are to be dammed and the rewards of enterprise deep-frozen.

In his speech surveying the economic outlook, Mr. Gaitskell seemed to infer that rising dividends lately were a factor in raising the cost of living. The Socialists, however, speak with two voices, for Mr. Harold Wilson, till recently President of the Board of Trade, said at the week-end that no one believed that dividend limitation would have any direct effect on the cost of living. Why, then, this swageing blow to industry and trade? It cannot be because the Chancellor is himself against the making of profits; only three months ago, in introducing the Budget, he recognised the function of profit as an incentive in an economy, three-quarters of which is run by private enterprise. It is, in fact, a sop to the dissidents who decry the profit motive, and in doing so betray abysmal ignorance. These people cannot see that profit only comes after everything else has been satisfied; moreover, they ignore the declaration of one of the U.K. productivity teams recently returned from the United States that 'a company which cannot make a profit will become a liability to owners and employees.' Dividend increases are negligible compared with the inflationary pressure on living costs that is already being caused by higher import prices and by wage increases. The former have run into a hundred million pounds; the latter are

officially estimated at £2,750,000 a week. 'The rise in dividends represents perhaps one part in fifteen hundred of the nation's total expenditure,' observes a writer in *The Economist*. To pretend that it is a prime cause of inflation (adds the writer) is politics, not economics.

The new limitations fall with grim severity upon the chemical industry. Throughout the post-war period our chemical companies have pursued expansive policies. Productivity has been vigorously increased. In many cases the total amount of capital actually employed in financing production is grossly understated in annual balance sheets since pre-war assets are still valued by pre-war standards. The illogicality of this is shown every time plant requires replacement. The rate at which profits have been ploughed back into businesses could hardly be increased. Now, when for most branches of chemical manufacture there is a sharp increase in the capital needed to finance each ton or each £100-worth of output, the dividend payments of all large companies must be kept at their previous rates. Mr. Gaitskell penalises most of these companies which fully supported the voluntary limitation of dividends policy of his predecessor. Those companies which have recently thawed a little of the voluntary ice stand in a less restricted position. They are cooled, perhaps, but not super-cooled. The compulsory freeze does not apply to dividend distribution not exceeding £10,000 gross. This will perhaps attract new capital to small rather than large organisations. It may be questioned, however, whether this will bring much benefit to the chemical industry as a whole. Most of the fundamental materials for chemical industry are held to be more economically produced by large organisations in large working units. Smaller companies and smaller works best fulfil their purpose when they devote themselves to specialised and secondary kinds of production. The exclusion of smaller businesses from Mr. Gaitskell's 'ice age' may tend to encourage productive effort that is less economic. At the same time small and enterprising companies developing new products and processes will not be discouraged. The extent to which these adverse and beneficial consequences will balance remains to be seen.

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Notes & Comments

Sulphur—At Last!

WHAT looks like being the answer to a maiden's prayer for all those scarce of sulphur in its elemental form (that is, everybody), is a catalytic process just emerging from its pilot plant stages in America for the recovery of pure sulphur from gases. Anyone who is in the unfortunate position nowadays of disgorging any part of the 60,000 tons of good sulphur yearly that goes up in smoke from coke ovens alone, or is engaged in making laborious and costly efforts to extract it by means of oxide boxes, solvent processes, catalysts and all the other paraphernalia of sulphur regeneration, may well prepare themselves for a shock—and a pleasant one. Although the 'Ferralyst' catalytic process for the recovery of sulphur in pure elemental form from waste gases has been in the research stage for several years—springing originally from Australian Government wartime research—this is the first time it has hit the news. And it is, as far as sulphur recovery plants go, revolutionary. For full details and performance reports, turn to page 143. Briefly, here are a few of the more striking facts about it.

It is a one pass process, reducing the sulphur content of any gas *in one pass* down to 0.0829 grains per 100 cu. ft.—clearing the gas of both organic and inorganic sulphides. It recovers the sulphur in the vapour phase, either as pure sulphur or as SO_2, whichever is desired. It operates at any space velocity between 10 and 10,000 catalyst volume changes per hour, at pressures between 1 and 20 atmospheres and at temperatures between 110°C. and 250°C. Far from requiring energy to operate it, the process is exothermic and heat may be recovered in the form of 100-150 lb. steam. The catalyst is cheap, does not foul, and *requires no regeneration.* Lastly, the floor space required is negligible compared with any known recovery process.

It is an odd circumstance that reports of this process have come to hand at exactly the same time as a report by the Industrial Gas Development Committee on the catalytic removal of sulphur from town gas. The 'Ferralyst' process becomes the more striking by comparison. Using a nickel catalyst, the North Thames Gas Board pre-heats its waste gas to 280-320°C., and converts the CS_2 and COS to SO_2, some of which is reduced again unavoidably to H_2S. The treated gas then has to be alkali-scrubbed to remove the SO_2, and then passed through an oxide box in the usual way to remove H_2S, with all the tedium and unsatisfactory results that this process involves. Thiophene, says the report, cannot be removed from gas by any practical chemical method—only by physical methods involving simultaneous separation of the benzole present. It is a remarkable fact that the 'Ferralyst' process not only removes thiophene and CS_2 and COS all in one operation, but also all the other evil-smelling organic sulphur compounds, converting them into pure sulphur or SO_2. Neither is there any energy lost in preheating the gases, except with very low sulphur content gas.

Questions in the House

THE subject is made topical by questions asked of the Minister of Fuel and Power—Mr. Noel-Baker—by Mr. R. S. Russell (Member for Wembley South) in the House of Commons on 23 July. Asked what steps were being taken to recover sulphur from power-station flue gases, Mr. Noel-Baker replied that research was going on but that no satisfactory method had yet been found. On being asked whether he could not consider allotting a subsidy to recover sulphur from coal carbonisation, Mr. Noel-Baker said that the capital costs of sulphur recovery would be £60,000,000 and the cost of the sulphur recovered £20 a ton as against £13 for it at present. He referred to a method of obtaining various sulphur compounds (ammonium sulphate and so forth), by which he evidently meant an I.G. Farbenindustrie process which uses an ammonia wash to remove the H_2S, now carried out under licence in Britain (*see* CHEMICAL AGE,

2 June 1951, p. 857). The ammonia used in this process constitutes much of the expense. (For another catalytic method of obtaining sulphur from gases, see CHEMICAL AGE, 9 June 1951, p. 877.) With the 'Ferralyst' process, the Minister has the answer to all his flue gas problems and a great many more besides. It is to be most earnestly hoped that he will not allow the money already spent on previous, less desirable processes by Government research organisations to hinder switching over to an obviously better recovery process. It has not been entirely unknown in the past for Government Departments to be reluctant to abandon their progeny when these have been the product of much hard labour, regardless of efficiency, but with sulphur so scarce today, considerations of a face-saving character should not be allowed to stand in the way of schemes greatly to the country's benefit.

Planning Industrial Research

'FAITH is the substance of things hoped for, the evidence of things not seen', with this quotation Dr. P. Dunsheath, C.B.E., concluded his masterly summing-up of the papers and discussions on the planning and financial control of industrial research at the second conference of industrial research directors and managers, organised by the FBI Industrial Research Committee, and held at Ashmore Hill, Leamington Spa, towards the end of last year. This indeed seemed to be a key point for without faith there can be no research, and the consequent problems would not therefore arise. Many interesting points were raised at the conference, the report of which has now been published (Federation of British Industries, 3s.), the three main sessions being devoted to the planning and budgeting, costing, and evaluation of research. Opening the first session, Mr. C. Paine (Imperial Chemical Industries, Ltd.), showed how planning and budgeting must go together and he emphasised two important points, the selection of the project to be followed and the subsequent planning of the work. The first point raised a question which recurred frequently throughout the conference—the extent to which the programme of a research department should be controlled or even influenced by other departments in the concern. It was appreciated that one important aspect was the difficulty of presenting the research programme in non-technical terms so as to convince the company's board that the proposed expenditure was justified—especially in long-term projects. Nevertheless, risks which might result from priorities being settled by a committee on which the research director was overborne by commercial immediacy, were fairly faced. Detailed costing of research was considered by some to be a discouragement to the research worker, who cannot be expected to produce original ideas at predetermined intervals. Evaluation of research proved hard to define, although the necessity for it was appreciated,. So many long-term factors influence the result between the event and the evaluation. The nearest approach to assessing the value of research seemed to be based on the numbers and value of patents arising from the research department. This was, however, quite rightly, not considered as a satisfactory yardstick. Such an interchange of opinions and discussion as took place at the conference should prove of real value in overcoming the complexities of planning industrial research.

Tungsten Control

FOLLOWING the allocation of tungsten ores by the International Materials Conference and its request to member governments to exercise control over both exports and imports, and render returns to it, the Ministry of Materials on 30 July became the sole importer and distributor of tungsten ores and concentrates in the United Kingdom. Successful international control of this metal is not going to be a simple matter. Unlike sulphur and molybdenum, more than 90 per cent of which come from the U.S.A., tungsten ore is fairly widespread over the globe. At the present time slightly more than half the world supplies comes from Brazil and Portugal, but the remainder is split up between Spain, Australia and a number of other countries. Co-operation between producers and consumers with the IMC is therefore essential if any international allocation is to succeed.

New Sulphur Process

Economic Recovery From Gases

FIRST discovered in Australia, but now emerging from its pilot plant stages in America, is a remarkable catalytic oxidation process for the production of elemental sulphur from waste gases. This process, called the 'Ferralyst' process, oxidises organic and inorganic sulphur compounds in one pass through a non-fouling catalyst either to elemental sulphur, or, depending on the conditions under which the process is operated, to sulphur dioxide. The catalyst in no way changes the constituents of the gases or vapours, but has a selective action on all such sulphides as hydrogen sulphide, mercaptans, dimethyl sulphide, thiophene, carbonyl sulphide, carbon disulphide, and the like. The total sulphur content of gases, both of a reducing and oxidising nature, can be reduced in the dry vapour phase by this means to less than 0.0829 grains per 100 cu. ft.

The performance of the process is high over a wide variety of conditions. With hydrocarbon gases the process operates over a temperature range of 110-240°C. for the production of elemental sulphur, and between 110° and 400°C. for the production of sulphur dioxide. The operating pressure may be from 1-20 atmospheres and the space velocity (catalyst volume changes of gas per hour measured at S.T.P.) may vary from 10 to 10,000, the upper limit being governed by the total sulphur content of the feed gases and the means provided for removing the exothermic heat of reaction in order to maintain the reaction temperature relatively constant. In the case of comparatively high sulphur contents, where the exothermic heat must be removed, tubular reactors are used with the catalyst placed inside 2 in. I.D. tubes and the temperature controlled by the generation of steam in a boiler shell outside the tubes at a constant predetermined pressure corresponding to the desired reaction temperature, as shown in the diagram.

Reactor Size

Reactors can be of a size to handle any volume of gas, but for purposes of illustration the diagram shown overleaf is of a unit which handles 2,000 cu. ft./hr. of gas. A plant like this, 10 ft. high but 3 ft. wide and containing fifty-two 2 in. tubes, can desulphurise 100,000 cu. ft. of gas per hour. The reactor is made of ordinary boiler steel. If gases of low sulphur, say less than 36.0 grains/100 cu. ft. content have to be treated, heat must be supplied to maintain reaction temperature, and the catalyst is placed in a hollow reactor in one mass and heated preferably by means of closed steam coils situated in the fixed bed, automatically controlled from the bed.

Catalyst Details

Regarding the catalyst employed by the 'Ferralyst', this consists of a mixture of active iron sulphides, sodium sulphide and sodium sulphite, and, depending on the degree of desulphurisation required, it may or may not be deposited on a catalyst carrier such as kieselguhr. It is, therefore, cheap. It is used in the form of irregular granules ¼-½ in. in size, and does not chemically foul except in the presence of relatively large quantities of cyanogen (more than 60 grains/110 cu. ft.). However, the reaction being a surface one, the catalyst can foul mechanically through tar, oil fog, dust or carbon deposition. In normal circumstances, however, it does not foul, and it does not need regeneration.

Being completely automatic in operation, the 'Ferralyst' plant is expected to operate at the cost of depreciation plus general maintenance and supervision, less the value of the sulphur and steam (6,000 lb. per ton of sulphur) recovered. Where sufficient sulphur is contained in the gas, the plant will desulphurise the gas at a corresponding profit.

By variations in the pre-treatment of the catalyst, the process can be operated in any of the following three separate ways:—

1. To absorb the sulphides in the gas—here the catalyst eventually becomes fouled.
2. To convert totally to sulphur dioxide, which can then be scrubbed out in a standard caustic wash.
3. To convert partially to elemental sulphur, in which case the sulphur is recovered in a liquid sulphur scrubber or a centrifuge. The sulphur comes over as a finely divided mist entrained in the gas stream after

passing over the catalyst. No sulphur deposits on the catalyst.

A valuable sideline of this process is its ability to provide steelworks with sulphur-free gas, and to diminish the odour and effluent problems of gas purification generally, as there is no effluent problem from 'Ferralyst' plants.

The results of a number of pilot plant operations in Australia and America, where it is expected that the first commercial plant will have finished buildng within six months, are as follows.

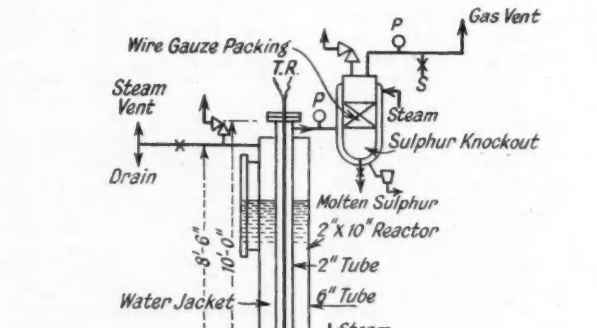
The original development of the 'Ferralyst' process was during an Australian Government wartime investigation into the synthesis of liquid and gaseous hydrocarbons from industrially produced blue water gas. The catalysts employed are intolerant of sulphur in any form in excess of 0.0829 grains per 100 cu. ft.

The 'Ferralyst' process treated more than 1,000,000 cu. ft. of gas during these tests and reduced the total sulphur content of these gases below the tolerable limits. The inlet gases were free of H_2S but contained from 14-18 grains of organic sulphur compounds per 100 cu. ft. These organic sulphur compounds consisted of thiophene, carbonyl sulphide, methyl and higher mercaptans, and carbon disulphide. A typical analysis of the gas was:—

CO_2—5.0 per cent; C_nH_m—0.2 per cent; O_2—0.3 per cent; CO—39.4 per cent; H_2—52.6 per cent; N_2—2.5 per cent. Inlet total sulphur—16.7 grains/100 cu. ft. Outlet total sulphur—less than 0.1 grains/100 cu. ft. In all these tests the process was used as a sulphur-absorbing process and no elemental sulphur or sulphur dioxide recovery was attempted.

Following the successful application of the process to synthesis work, it was then applied to the desulphurising of furnace atmospheres in the bright annealing of metals. For this application, research was done on a pilot commercial scale using city gas—partially purified—and raw coke oven gas as the source of the atmosphere. For successful bright annealing, the total sulphur content of the furnace atmosphere must not exceed 0.75 grains/100 cu. ft. In an extended continuous commercial test over a period of two years on city gas, 'Ferralyst' reduced the total sulphur content of the gas to below 0.5 grains/100 cu. ft. A typical analysis of the gas was as follows:—

CO_2—4.9 per cent; O_2—0.2 per cent; C_nH_m—3.6 per cent; CH_4—19.7 per cent; CO—26.8 per cent; H_2—41.2 per cent; N_2—3.6 per cent. Inlet total sulphur—21.3 grains/100 cu. ft. Outlet total sulphur—0.5 grains/100 cu. ft.



In this gas the H_2S and tar fog had been removed, but it still contained its full complement of benzene, toluene, xylene, etc.

In another continuous commercial test, the process was operated on raw coke oven gas from which only the tar fog had been removed. This test was ru... for a period of two months. A typical analysis of the gas was as follows:—

CO_2—3.8 per cent; O_2—0.3 per cent; C_nH_m—3.2 per cent; CH_4—21.9 per cent; CO—23.5 per cent; H_2—44.5 per cent; N_2—2.8 per cent. Total inlet sulphur as H_2S—319.6 grains/100 cu. ft. Ditto as organic sulphur—23.1 grains/100 cu. ft. Total outlet sulphur—0.43 grains/100 cu. ft.

In all the above gases the organic sulphur compounds consisted of a mixture of thiophene, carbonyl sulphide, mercaptans and carbon disulphide. In all the tests so far described the process was operated to convert the sulphides, both organic and inorganic, to elemental sulphur.

The process was next applied to a paper industry to convert the sulphides in the digester and evaporator gases into elemental sulphur or SO_2. These gases had a sulphur content which varied from 5-43 per cent by volume, and the process effected a 98-99.99 per cent recovery of this sulphur either as elemental sulphur or SO_2, as desired. Tests on a pilot-commercial scale, successfully treating all gases from a 150 ton-per-day mill, were conducted over a period of one year. A typical analysis of the type of gas treated was as follows:—

CO_2—5.4 per cent; O_2—18.2 per cent; CH_3SH—7.9 per cent; $(CH_3)_2S$—5.3 per cent; H_2S—8.6 per cent; N_2—54.6 per cent.

Recovery from Smelters

Research was also undertaken with the object of applying the process to the smelting industry to recover elemental sulphur from the SO_2 content of waste gases from ore roasters, etc. Before the 'Ferralyst' process could be applied, however, means had to be found of converting the SO_2 to H_2S. This was accomplished by passing the SO_2-containing gases, together with steam, through a bed of incandescent carbon such as coal or coke. A large semi-commercial pilot plant was erected with a gas throughput capacity of up to 20,000SCF/hour, and continuous tests resulted in the recovery of 98-99 per cent of the original SO_2 as elemental sulphur. The following is a typical analysis of the gas entering the 'Ferralyst' unit:—

CO_2—4.0 per cent; O_2—3.6 per cent; CO—22.0 per cent; H_2S—4.5 per cent; N_2—65.9 per cent.

Work was also undertaken at an oil refinery for the purpose of removing residual carbonyl sulphide from the refinery propane stream. This gas contained 5-40 grains of COS per 100 SCF. The pilot unit supplied by the refinery had a gas throughput capacity of 300-600 SCF and was operated at 80-100 p.s.i. Difficulties were experienced in maintaining a relatively dry (from H_2O) feed gas to the unit with the result that the catalysts became wet, and thus caked and channelled. Catalyst also became severely overheated and in some instances bed temperatures rose above 1,200°F. This resulted, apparently, in some structural change of the catalyst surface, as it was noted that, at the pressures employed, the SO_2 formed by the catalyst was converted on its surface to other organic sulphides. However, good results were obtained but were not continuous owing to plant mechanical difficulties causing temperature conditions in the catalyst bed with side reactions.

H_2S and Air Mixtures

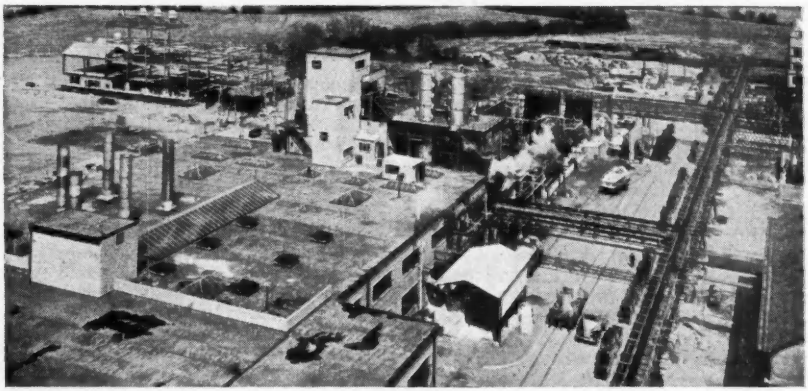
At the same time as the refinery work was proceeding, a chemical concern conducted a pilot scale investigation at its New Jersey works, into the production of elemental sulphur from mixtures of H_2S and air. During a continuous test of approximately 100 hours duration, conversions of up to 99.8 per cent were obtained at space velocities of up to 3,000, when stabilised operating conditions were maintained. A typical analysis of the feed gas was:—

$H_2S - 10.1\%$; $O_2 - 18.5\%$; $N_2 - 71.4\%$

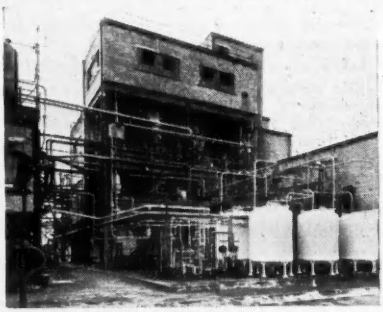
In America now, the 'Ferralyst' plants will first be placed in Kraft pulp mills, Girbitol H_2S effluents from oil refineries, etc., and natural gas (some of which streams contain 25 per cent H_2S), but the development in Britain, which is being studied now by Mr. A. M. Ross-Smith, director of the Ferralyst Desulphurising Corporation of New York, is likely to be towards commercial application of the process so that the 50,000 odd tons of sulphur now lost to the air from coke ovens may be cheaply, quickly and effectively recovered, and that sulphur may be recovered in pure elemental form from the domestic gas industries with the replacement of the old oxide boxes.

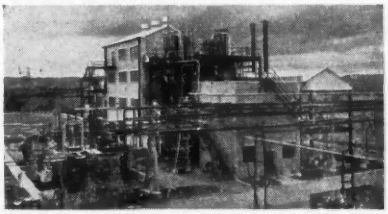
A Well-planned Chemical Works

Monsanto's 'Large Scale Laboratory' at Newport

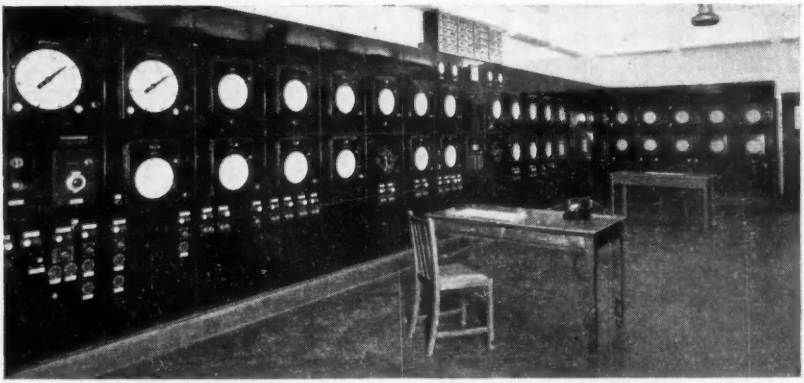


General view of the 'Santomerse' building, showing the progress at Newport





Exterior of the 'Aroclors' plant, and (left) a rear view of the DDB plant



The 'Santomerse' unit control room from the plant end

The Structure of Coal

New Belgian Evidence for a Molecular Entity

ON this controversial and much debated subject Professor Alfred Gillet, of Liège University, in a paper read at a meeting of the Société de Chemie Industrielle, last January, expresses the view that some real progress may be expected through controlled oxidation, both on the basis of his own experiments and those of the U.S. Bureau of Mines (*Chimie et Ind.*, 1951, *65* (5), 641-645—May).

Belgian research has certainly made some interesting contributions to a difficult subject during the past quarter of a century, in which special reference should be made to the work of M. L. Crussard (Belgian) Inspector General of Mines,[1] and of the present author and co-workers.[2] The latter in 1929 said that coal is a true colloid, and from this aspect some fruitful explanation is possible, furnishing guidance on plastifying solvents for coal, and various reagents. But for more than 20 years success along these lines appeared only partial, and it is only during the past year or two that Professor Gillet can claim to have new views based on experiment, and a more or less definite and firmly based hypothesis on the structure of coal.

He describes the molecule of coal as a well defended fortress, and asks whether it should not still be regarded as a mystic shadow, a mirage, as Crussard had earlier suggested. Before attempting an answer he deems it expedient to define some terms, such as molecule, molecular groups, macro-molecules, and sub-molecules; and this he does from the points of view of both chemist and physicist, in which of course the relative strength and nature of bonds or linkages between these various units or groups are of fundamental importance. Are these bonds electronic, atomic, molecular, or 'Van der Waals cohesions'?

No Volatilisation

The first point to note is that coal does not volatilise, or rather that the so-called volatile substances derive from transformations much more complicated than mere vapourisation, and in any case only affect a small fraction of the whole. On the subject of coal crystallisation the author has elsewhere expressed his views.[3]

A further point is that the most important coals melt. The vitrain of a fat coal is converted wholly into a liquid which at about 450°C. has the viscosity of a lubricating oil at ordinary temperature. This fusion is the basis of coke formation from powdered material or fines, of methods of judging coking coals, and of pyrolysis with complete carbonisation.[4,5] Still more important is the apparent possibility of dissolving coal, in accordance with the well known Rütgerswerke patent of 1918, and the proposals of S. E. Sheppard & L. W. Bates in the U.S.A. for producing colloidal fuels.[6]

Results Doubted

These ideas suggested further lines of investigation to Gillet who hoped thereby definitely to clear up the problem of coal structure, and he recorded some results in 1931 at the 3rd Congress in Pittsburg. Apart from a few 'informed specialists', however, these results were regarded with considerable scepticism and, in the author's opinion, a certain amount of prejudice, as exemplified by an English scientist. The latter reminded him—'It is well known that coal is a complex mixture of substances differing in molecular weights and possible structure'.

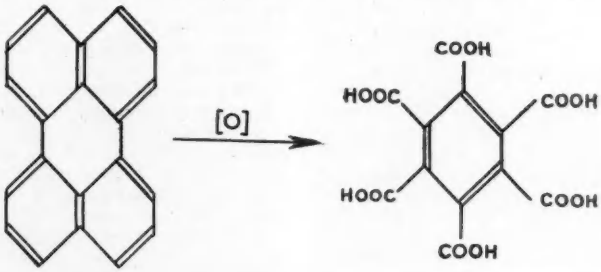
In their well-known researches with coal extraction by solvents, Wheeler and co-workers had used phenanthrene (b.p. 340°C.) instead of pyridine (b.p. 115°C.) as first solvent; but it was not 30 per cent only of coal that was extracted and called α and β constituents. It was more nearly a 80-90 per cent extract that could be precipitated and redissolved at will. These results and those of the author with anthracene oil seemed to suggest that coal is a much more uniform, or could we say homogeneous, material than commonly supposed—at least to the extent of about 80 per cent. Turning now to the published researches of the U.S. Bureau of Mines[7] by G. Golumbic *et al.*, on the action of phenanthrene on coal, the author has repeated these and confirmed the results. These, together with the earlier work of Wheeler are experimental facts incontestable as such, and one may well ask why then they are seemingly contradictory.

This contradiction cannot be in the facts themselves but in their interpretation. What

sort of picture do the facts as a whole present? Gillet suggests that what may be called the basic material of a fat coal may be dissolved up to 80 per cent or more, at a high temperature, very quickly, in vigorously active solvents such as phenanthrene at about 350°C., and in naphthol at about 290°C. This basic material exhibits many of the characteristics of a molecular entity: it passes definitely into solution; it separates therefrom with constant composition, without fractionation; and its behaviour towards fusion, pyrolysis, oxidation and possibly towards crystallisation supports this. Yet this apparently homogeneous material decomposes very readily, and through changes almost unperceived breaks down into several other substances. And it is these products of decomposition that the earlier researchers have separated out, giving birth to the idea of 'a very complex mixture'.

Gillet found in his solution the effects of this same decomposition, the products of which Wheeler and his school have collected. Solution of the coal in anthracene oil is a transient stage, and that which is re-precipitated spontaneously, after having been carried into the solution in the complex which it forms with other materials, is the insoluble humin of Fischer and the α-fraction of Wheeler. In every case the coal undergoes the same decomposition; but with high temperature solvents (300-400°C.) decomposition takes place *after* solution, whereas with the low temperature solvents it occurs *before*, permitting the bitumens to pass into solution in media where they alone are soluble, excluding the humin. The great practical difference between the two kinds of solvent is that the high temperature solvents dissolve the humin, and if this is so it is precisely because the humin has not had time to separate out from the bitumens group or combination. It is only in such combination that it is solubilised for anthracene oil; and as soon as the combination is broken up —after an hour or two of heating or only a few minutes—the humin is reprecipitated.

It seems then that there is indeed a molecular entity, a basic material, somewhat unstable and readily splitting up into humin and bitumins, of which it is now necessary to study the structure, at least the structure of the humin, for the bitumins despite their importance must be left for the time being. Humin forming about 70 per cent of the coal should probably be regarded as the truly basic material in its structure. In connection with this part of his work the author refers to the discovery of the oleo-carbons or fat coals.[8] Of the 29 carbon atoms in coal, 26 are to be found in a substance which combines in definite proportion with one molecule of oleic acid. The product is soluble in benzene. Another oleo-carbon is even soluble in aliphatic hydrocarbons—in ether and benzine (petrol). In this way coal may therefore literally dissolve in petrol.[9] But these products are still unfortunately unstable, and the final assault on the problem is still far from achieved.



I II

On the subject of oxidation to which brief reference is made in the article, it seems that little real knowledge of coal structure has emerged except possibly in connection with the benzene-polycarboxylic acids containing nearly 50 per cent (12 out of 29) of the carbon atoms of the original coal. In their simplest form they consist of groups of benzen nuclei, such as (I). Oxidation of such structure would produce in the first place mellitic acid, (II) and then by successive decarboxylations, the various acids—

[continued on page 150

Poland's Six Year Plan

Independence From Imports Sought

POLAND'S Six Year Plan is now in its second year. Some of the new chemical works to be erected under the plan are already in partial production, others are in course of construction, and there is now sufficient evidence for an assessment of the practical achievements of the Polish chemical industry.

In the eastern bloc Poland ranks third as producer of chemicals behind the Soviet-Union and Eastern Germany. She is favourably placed for an expansion of chemical production because of her large coal deposits in Upper Silesia, the availability of cheap electricity and abundant supplies of other chemical raw materials including salt, gypsum and various minerals and metals, especially zinc. The oil and potash deposits in eastern Galicia have been lost to Russia, and Poland also lacks indigenous resources of sulphur and phosphates. Potash and phosphates, however, are obtained regularly under trade agreements from Eastern Germany and the Soviet-Union respectively.

The Six Year Plan provides for a big expansion of the production of heavy chemicals and nitrogenous fertilisers, for development of the organic chemicals industry, more particularly the manufacture of raw materials for synthetic fibres and plastics, and for the production of a number of new preparations, especially pharmaceuticals, dyes and insecticides. In other sections of the chemical industry production is to be raised in line with the expected increase in demand, but most of the 25 new works and 22,000 additional workers are to be employed on the production of heavy inorganic chemicals, fertilisers, organic chemicals and new pharmaceuticals.

Increasing Output

The production of nitrogenous fertilisers is to be trebled by the end of the Six Year Plan. It is now confidently expected that this year it will already be more than 40 per cent higher than in 1949, owing to the repair and modernisation of the existing works at Moscice and Chorzow. A third big fixation plant is under construction at Kedzierzyn and will come into operation in 1953; when completed, it will produce more nitrogenous fertilisers than the big works at Moscice. A fourth fertiliser plant is to be erected by 1955.

Sulphuric Acid Problems

No new superphosphate factories are apparently to be built in the next few years because the existing capacity is far from fully utilised. The reason for the insufficient superphosphates production is to be found in the shortage of sulphuric acid and sulphur-bearing materials. Before the war sulphuric acid was produced in Poland almost entirely from zinc ores and pyrites. It is now hoped to produce sulphuric acid from gypsum by the process developed by German chemists at Wolfen, the former I. G. Farben factory now operated by a Soviet Corporation in Eastern Germany. But even if these plans succeed, Poland's sulphuric acid output will be only about a quarter higher than before the war, and the whole additional production will be needed by rayon, dye and paint factories so that the superphosphates industry is unlikely to obtain more acid than at present.

Two new soda factories are under construction at Wizow and Ostrow, and the production of caustic soda and, still more, of chlorine is to be increased substantially. Production of organic chemicals has begun at a new works at Dwory in Silesia; methyl alcohol, acetic acid and acetic anhydride are reported to be in production at this plant which is also producing synthetic petrol and experimenting with the production of high-octane spirit, so far only on a laboratory scale.

Another new organic chemicals plant recently reported in part production is situated at Brzeg. It is eventually to make 120 different intermediate and finished products, including dyes, drugs and insecticides. Finished products are later also to be made at the Dwory plant, in particular, plastics, while synthetic fatty acids, synthetic waxes, solvents and plasticisers will be made at the Kedzierzyn plant if present plans are proceeded with.

Synthetic fibres and plastics are being made at a new big works which was recently

officially opened at Gorzow. The production programme includes artificial fibres, foils, plastics and varnishes. The output at present seems to be confined to artificial fibres, of which one or two tons a week are being made; later the output is to be stepped up to 'many tons a day'.

Indigenous Raw Materials

Polish Government spokesmen have laid stress on the importance of the new plants for making their country independent of imports. Maximum use of indigenous raw materials is certainly one of the main objectives of the plant expansion under way. Eventually it is hoped to replace imported potash by exploiting deposits discovered in recent years in the region of Poznan. Use is being made already of peat deposits in the northern part of Poland and of natural gas. A new factory for tanning materials at Bydgoszcz is to use oak, willow and pine bark.

Besides this, the Polish authorities hope to extend their export trade in chemical products, especially in zinc pigments which are being sent in substantial quantities to the Scandinavian countries and also to Brazil and China, and in coal-tar products which are produced in large quantities in the by-product plant of the Upper Silesian coke-oven industry. These two main groups of Polish export chemicals, however, are produced in existing plant, the capacity of which exceeds local requirements, and no new investments seem to be envisaged in these sectors of the chemical industry, a fact which bears out the view that the Polish authorities aim at self-sufficiency in the chemical field rather than at expansion of those chemical productions where the country enjoys a natural advantage as supplier for the world market.

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continued from page 148]

penta, tetra- tri- and di-carboxylic. It is thus concluded that controlled oxidation opens up the most promising road towards elucidating fully the structure of coal.

In 1947 Professor Gillet read a paper at the London Congress giving some preliminary results, but up to the present this paper has not been published. In December last, in the U.S.A., some work by L. D. Friedman and C. K. Kinney, of the Pennsylvania State College, was also reported,[10] the results of which appear in complete agreement with those obtained in Belgium. These relate to the complete transformation of a coal into an acidic product soluble in aqueous alkali-regenerated humic acid. This had indeed been shown long ago by Wheeler and F. Fischer, especially by the former who discovered some very interesting characteristics in these products; but neither seems to have realised the full significance of the reaction.

Of the total 29 carbon atoms in coal 20 with sufficient accuracy remain associated with the reaction product, which is still black like coal. From this and other considerations Gillet concludes that oxidation does not disturb the general arrangements of carbon atoms in coal. This 'regenerated humic acid' appears to consist of a homogeneous (*unitaire*) material. It undergoes definite physical change (*e.g.*, flocculation) under given *p*H conditions, and has definite weight (equivalent weight) in an acid reaction (*par fonction acid*). There are grounds for hope of rapid advance in this direction, namely in the further study of this material and its constitution. Professor Gillet remarks that this is another story which must apparently be reserved until a later time.

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2,4-D in Canada

Canada's largest city, Montreal, has begun its sixth successive year of campaigning against ragweed, the pollen of which is responsible for bringing misery to thousands of hay fever sufferers annually. A fleet of jeeps converted into sprayers are systematically dousing weed-infested lots, playgrounds, golf courses and parks in the Montreal area with the selective hormone weedkiller, 2,4-D and will continue their work well into the autumn.

Synthetic Resin Glues

Wider Application Possible

DURING recent years a number of adhesives have been introduced for making joints in aluminium alloys. Despite certain defects, such as poor resistance to tearing stresses, the strength of glued joints is sufficiently high to merit consideration of the use of adhesives in stressed aircraft structures. It has been claimed that the shear strength of glued lap-joints exceeds the strength of comparable riveted or spot-welded joints. The chief advantage to be gained from glued joints, however, would be not an increase in strength, but greater facility in the production of structures possessing a very smooth surface. Other advantages claimed are that glued joints are pressure-tight and since the adhesive layer is a non-conductor the possibility of electrolytic corrosion in joints between dissimilar metals is reduced. Apart from application in aircraft construction, a reliable adhesive could be widely used with light alloys in many industries.

Research work carried out under the direction of the Ministries of Supply and Aircraft Production, now combined as the Ministry of Supply, has elucidated many problems associated with the development and behaviour of synthetic resin glues. The main criticism of existing glues is that the technique of joint-fabrication is critical and not suited to full-scale production. Since inspection of all glued joints is virtually impossible, it is essential that the reproducibility of joints glued by production methods should be of a high order. With existing glues and techniques, however, much care is required even in the laboratory to make reliable joints.

Better Results

Preliminary work in attempting to overcome these disadvantages has been described by W. J. Roff and K. W. Pepper.* The objective was not a glue of higher strength than those already available, but the development of glues and techniques which are simpler in application and more reliable in results. To this end, it was proposed to examine systematically the effect of each factor involved in the fabrication of joints.

Many of the existing glues consist of mixtures of a linear polymer, *e.g.*, polyvinyl acetate or synthetic rubber, with a cross-linking resin, *e.g.*, phenol-formaldehyde or urea-formaldehyde. Preliminary tests showed that a simple mixture of this type would be satisfactory for further study. This mixture consisted of equal parts by weight of an aqueous emulsion of polyvinyl acetate, and an aqueous solution of phenol-formaldehyde resin. It was thinned with methanol to a 'syrup' of suitable viscosity. In later work, the aqueous emulsion of polyvinyl acetate was replaced satisfactorily by a solution of the polymer in aqueous methanol. The syrup could be spread evenly on clean aluminium strips and dried, on evaporation of the solvents, to a tacky film. If the coated strips were pressed together by hand at the tacky stage, then held lightly by clips and baked, good joints resulted.

Test Difficulties

Laboratory evaluation of any glue presents considerable difficulty. Even with wood glues, where the results of laboratory tests can be checked against experience gained from the performance of plywood, etc., over many years, completely satisfactory tests have yet to be developed. From a fundamental point of view it would be desirable to use a test which measures a single property of the glued joint; *e.g.*, static strength in pure shear. Even if it were possible to devise such a test, however, it is doubtful whether the results would have much significance when considering actual structures glued by production techniques, because only rarely in service are glued joints subjected to a single type of stress. A compromise was thus unavoidable, and for this investigation a simple lap joint, ½ in. by ½ in. in 1/10 in. duralumin, was chosen.

The duralumin strips as received from the workshop were contaminated with traces of grease and with the oil used for cutting. In this condition they were unsuitable for use. Cleansing was found to be effective in improving joint strength, and of various treatments tested degreasing in trichlorethylene

* Selected Government Research Reports, Vol. 7. Adhesives. (Published for the Technical Information and Documents Unit of the Board of Trade by HMSO).

vapour, followed by a chromic acid pickle, appeared to give the best results.

The investigators studied the effects of variations in the composition of the syrup on joint-strength and on other properties of the glue, and also the effect of variations in the conditions of bonding. It was concluded that bonding temperature had a marked effect on the strength of joints made with the mixture of polyvinyl acetate emulsion and phenolic resin. The proportion of polyvinyl acetate to phenol-formaldehyde had a major effect on the strength of the joints. Mixes of the two resins gave stronger joints than either of the resins by themselves, but a syrup containing 35 per cent vinyl resin gave anomalously low results. It was considered unlikely that reduction in joint-strength of the 35 per cent vinyl resin glue derived from reduced specific adhesion, since the effect was not observed in butt-joints, where the glue was subjected mainly to direct tensile stress.

It would appear at first sight that the 35 per cent vinyl-resin glue, although normal in tension, is anomalously weak in shear. In practice, however, these two properties are usually closely related, and a more probable explanation lies in the fact that in tests on lap-joints, considerable tearing stresses are involved. An explanation of the anomaly must await more precise and detailed examination of the properties of cured films and mouldings of varied composition.

Apart from these instances of critical composition and maximum temperature of cure, polyvinyl acetate/phenolic resin mixtures were shown to be tolerant to variations in conditions of joint fabrications. The values for failing loads were found to be relatively independent of the viscosity of the syrup or the atmospheric conditions at the time of its application. They were almost unaltered by likely variations in the thickness of syrup applied, in the age of the prepared surface or in the drying time used, and were but little affected by small changes in the bonding conditions or the interval between bonding and testing.

Change of Address

Since 28 July, 1951, the address of the Crack Pulverising Mills, Ltd., formerly of 49-51 Eastcheap, London, has been 'Plantation House', Mincing Lane, London, E.C.3.

Technical Manpower

Reconstituted Committee

SHORTAGE of scientists and technologists in the United Kingdom is a matter that has been causing concern for some time. With the additional requirements arising from the defence programme the problem has become one of increasing urgency.

To deal with the situation it has been decided to reconstitute the Technical Personnel Committee, which under the chairmanship of Lord Hankey, dealt so successfully with questions of scientific and technical man-power during the war and in the immediate post-war period.

Terms of reference of the new committee will be slightly wider than those of the original one. It will review the requirements for scientists and engineers at home, and especially those arising from the defence programme, in relation to the available supply. Consideration will also be given to what can be done to meet certain overseas needs for people of the same type.

Chairman Again

Lord Hankey has agreed to serve as chairman of the reconstituted committee and other members will be:—

Nominated by the Federation of British Industries: Sir Arthur Fleming, Sir Wallace Akers, and Captain A. M. Holbein; representative of the universities: Sir Edward Appleton: chairman of the University Grants Committee: Sir Arthur Trueman; representative of science (nominated by Lord President): Professor S. Zuckerman; Treasury: Mr. S. L. Lees; Foreign Office: Mr. E. A. Berthoud; Colonial Office: Mr. R. A. Whittle; Board of Trade: Mr. S. A. ff. Dakin; Commonwealth Relations Office: Mr. A. C. B. Symon; Ministry of Labour: Mr. H. M. D. Parker; Ministry of Supply: Mr. W. D. Wilkinson; Lord President's Office: Mr. E. D. T. Jourdain. The secretary will be Mr. A. J. S. James, Ministry of Labour.

Outside Interests Consulted

The committee will be empowered to invite representatives from other Government departments or outside interests to be present when matters of concern to them are being discussed.

Metallurgical Section

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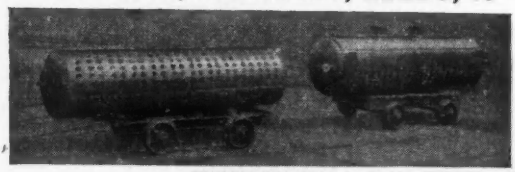

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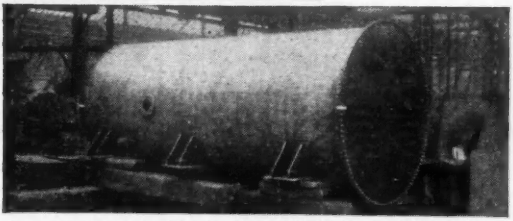

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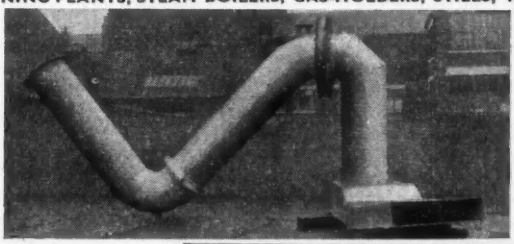

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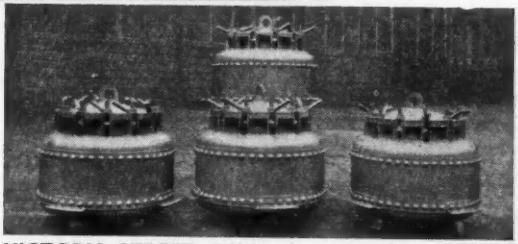

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Metallurgical Section

Deformation and Corrosion

Recent Russian Work on the Corrosion of Metals

THE effect of deformation on the corrosion of metals is of great practical importance in view of the fact that deformation may frequently occur in the common processes of pressing, machining, or other operations on metals, including also various forms of heat treatment. E. M. Zaretskii has reviewed some of the general ideas and factors involved in a study of corrosion as affected by deformation, and described tests with various magnesium alloys, steel, copper, zinc, and aluminium, exposed to various forms of deformation and to different corrosive media. (*Zhurn. Prikladn. Khim*—Journ. of Applied Chem.—1951, *24* (5), 477-484—May).

He considers that so far there has been little systematic research in this field, although certain experimental data of Russian origin indicate that corrosion combined with tensile stress often alter the picture of metallic fracture[1,2] and that, generally, deformation accelerates corrosion.[3] Some doubt is thrown on the comparison made by Evans between deformation and elastic compression and his view that there is an increase in potential energy.[4] It is thought to be generally known that corrosive processes in most cases may be defined not as a storing up or increase of potential energy, but rather as a series of repeated effects, of formation and solution in electrolyte of oxide films with or without admixture of metal.

Determining Factors

Corrosion in association with deformation, on the theory of micro-elements (cells), is said to be connected with the following factors:—

1. *The nature or form of oxide films, in metals subject to deformation.*—In deformation there is breakdown of the protective oxide film, which affects resistance to corrosion. In the course of time this film may reform on exposed parts to a greater or lesser degree. Generally the films on deformed metals are less perfect, more porous or cracked, and thus they are more easily broken down by corrosive media. As a result of such breakdown the inert or passive parts of the surface covered with a relatively thick oxidic film may become anodic; and this may occur in parts where the film has acted as cathode. If corrosion proceeds under predominantly anodic conditions then an increase in the area of anodic parts—due to deformation—leads to a corresponding increase in the rate of corrosion. The presence of cathodic conditions (or limits) will favour a reduced rate of corrosion after deformation at the expense of a reduced area of cathodic parts.

Ohmic Resistance Decreases

2. *Reduced ohmic resistance of the micro-cells.*—Deformation is accompanied by break-down of crystallites, leading to an increase in the number of micro-cells, decrease in the dimensions of the micro-electrodes, and a corresponding decrease in the ohmic resistance of the cells.

3. *Part played in deformation of micro-anodes and cathodes.*—The relative degree of deformation of micro-electrodes depends on their plasticity, distribution and quantitative relation of structural constituents as well as the form and nature of deformation. Here it is well to note two extreme cases: if hard inclusions are distributed in a relatively soft matrix or basic phase then the basic constituent will be preferentially deformed; but if the inclusions are sufficiently plastic then both these and the basic substance may be deformed. Parts adjoining boundary crystallites are deformed to a lesser degree than in the central or inner parts. This may lead to the formation of new micro-cells.

4. *Micro-cracks.*—In deformation up to the point of fracture of the metal, micro-cracks are formed, as a result of which the surface in contact with the corrosive medium is augmented and corrosion is increased.

5. *Effect of deformation in accelerating break-down of the supersaturated solid solution.*—Formation of new phases leads to the emergence of auxiliary micro-cells and a corresponding increase in the rate of corrosion. Predominant break-down in boundary crystallites may involve a tendency to inter-crystalline corrosion.[5]

This brief review of some of the principal factors involved in the corrosion of deformed metals indicates very clearly the complexity of the subject.

Experimental

The effect of residual tensile deformation on corrosion was studied with the magnesium alloys MA-1, MA-8, and MA-3, zinc,

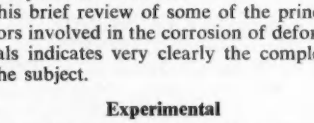

Fig. 1

aluminium, copper, and iron, the chemical composition of which is given in the original. All were used as rolled, and corrosion was measured by the loss in weight and yield strength. In a succeeding part of this paper results will be reported in connection with the effect of deformation on the potential of metals and the working of a model micro-cell of an Mg alloy. Specimens for corrosion and elongation (tensile) tests were as shown in Fig. 1.

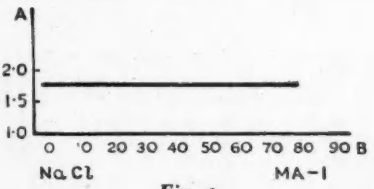

Fig. 2

Surfaces were prepared by degreasing and etching. In the case of Mg alloys the artificial oxide film was removed in a solution of chromic anhydride (CrO_3). After etching, and also after deformation, specimens were kept in a drier over roasted calcium chloride for 20-24 hours. In the corrosion tests the active surfaces of specimens was 12 cm². The non-worked part and ends were coated with adhesive (glue or the like) AK-20.

For each stage or degree of deformation no less than five tests (corrosion) were made in electrolyte of volume 20 litres at a temperature of 25°C. In order to maintain a constant *p*H of 6.8 a buffer mixture of 0.01 mol. NaH_2PO_4 plus 0.05 mol. NaOH was used. Usual duration of test was 24 hours.

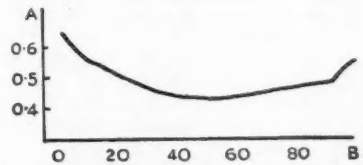

Fig. 3

Corrosion tests of the alloys were also made under atmospheric conditions for two years. In some of the tests, owing to the absence of definite results and to changes in the yield strength after corrosion at different stages of deformation, results are only given as loss in weight.

Mg alloys.—Specimens were 1 mm. thick, degreased in standard triphosphate solution[7] and immersed in 20 per cent chromic anhydride at 60°C. to remove the oxide film. After annealing at 420°C. for 3 hours, specimens were immersed in 10 per cent nitric acid for ½-1 min., and then deformed and weighed. Results are shown in Figs. 2-7 in the original, showing loss in weight in g/dm² (A) with increase in load, as percentage of yield strength σ_y(B). Composition of the three Mg alloys was: MA-1, 1.68 per cent Mn only (balance Mg); MA-3, 5.63 per cent Al, 0.96 per cent Zn, and 0.33 per cent Mn; MA-8, 0.15 per cent Al, 0.35 per cent Ce, and 1.67 per cent Mn. In the case of MA-3 and MA-8 another set of ordinates is

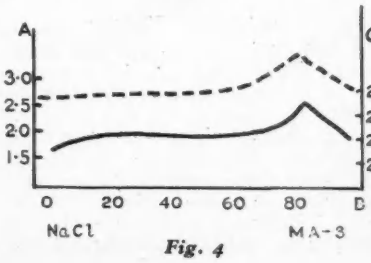

Fig. 4

included, *viz.*, the relation $\frac{\sigma - \sigma'}{\sigma} 100$ (C) shown in dotted lines.

Figs. 2, 4, 6, are for 0.1 mol. NaCl solution tests, while Figs. 3, 5, 7, are for atmospheric.

The general conclusion for Mg alloys is that residual deformation either does not materially affect the rate of corrosion, or slightly increases resistance to corrosion, both in NaCl solution and in the open air. These alloys in fact show high resistance. After two years' exposure in an industrial atmosphere the decline in yield strength of sheet material of about 1 mm. thickness was not more than 20 per cent for MA-3, 15 per cent for MA-8, and 5 per cent for MA-1 (containing 1.68 per cent Mn only). Of course the effect of deformation depends on its form and degree and on the corrosive medium. Bobovnikov found[8] that lowering the temperature of rolling increased the

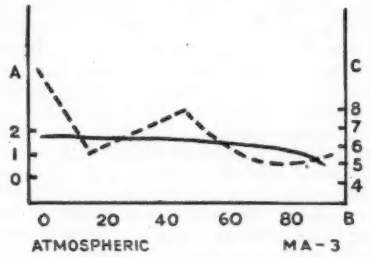

Fig. 5

corrosion-resistance of Mg alloys in 3 per cent NaCl solution and sea-water sprays. References to the literature show too that the rate of corrosion of rolled Mg in solutions of NaCl or HCl does not depend on the degree of cold- or work-hardening.[9] The same was found for MA-3 in distilled water after tensile deformation.[10] However, in some cases, lowered resistance to corrosion in dilute HCl is reported:[11] while in others, cold working, *e.g.*, by scouring or scraping, resistance of the Mg-Mn alloys in sea-water was markedly raised.[12]

The author also reports some of his own tests to show the effect of the corrosive medium and the nature of deformation. Specimens were cut from sheet Mg and alloys MA-1 and MA-3, etched in nitric acid, ground with emery No. 00, degreased with acetone, and immersed in 0.1 mol. NaCl solution. It was found that grinding or polishing considerably increased the corrosion resistance of Mg and alloy MA-1, but lowered that of MA-3. When tested in distilled water Mg and MA-3 showed less loss in weight than unpolished specimens. This may explain the sometimes contradictory results obtained.

The effect of deformation on the corrosion of magnesium alloys may be associated with

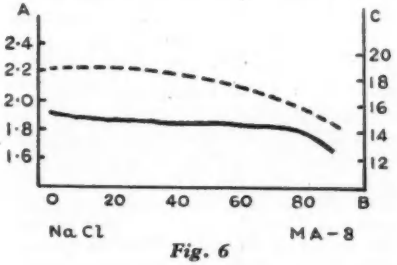

Fig. 6

changes in the relative anodic and cathodic areas. If it be supposed that the corrosion of magnesium alloys takes place with cathodic areas or limits predominating,[13] then deformation, or the breaking down of the oxide film which plays the part of the cathode, increases the anodic area at the cost of the cathodic, causing a reduced rate of corrosion. In alloy MA-1 the oxide film evidently is easily reduced, so that the rate of corrosion in 0.1 mol. NaCl does not depend on deformation. The appearance of minima or maxima on the corrosion-deformation curve in open air tests must probably

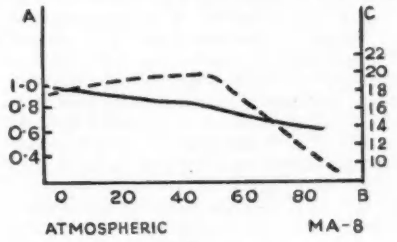

Fig. 7

be associated with the protective properties of the products of corrosion forming on the deformed surface.

[*for References, see page* 160

Substitution of Metals

German War Research Valuable

THE growing shortage of many metals is again directing attention to the possible substitution of alternative materials or methods of manufacture for those traditionally employed. Before and during the war the Germans were in the same position and showed great ingenuity in finding substitutes for such metals as tungsten, copper, tin, nickel and lead in a wide variety of jobs.

TIDU Documents

A wealth of information on German work on alternatives for non-ferrous metals and alloy steels is contained in intelligence reports and captured German documents. Some reports in English are obtainable either from His Majesty's Stationery Office or from the Technical Information and Documents Unit of the DSIR, Lacon House, Theobald's Road, London, W.C.1. Photocopies of German documents can also be obtained from TIDU, which, in addition, offers a translation service for organisations having staff with no knowledge of technical German. A survey of the literature on this important subject has just been published for the Technical Information and Documents Unit by His Majesty's Stationery Office.*

In order to avoid the use of scarce metals the Germans were forced to make significant changes in the compositions of many alloy steels. The outstandingly scarce alloying element was nickel, but molybdenum had to be reserved exclusively for high-speed steel for tools. In the structural fields chromium-molybdenum steels were replaced by chromium-vanadium and manganese-vanadium. Tungsten was available for tool steel and other essential purposes, but very little cobalt or columbium was to be had. Chromium became so scarce as to require careful control of its use and its full recovery from scrap. Methods were devised to minimise the loss of this metal in the furnace operation and produce minimum slag volume with consequent loss of chromium in the slag, attention also being devoted to the reduction of chromium oxide in the slag during the final stages of refining. At Krupps, for example, the slag was treated by additions of aluminium or granulated ferro-silicon.

The broad picture seems to be that at first, when nickel was scarce, chromium-molybdenum and chromium-molybdenum-vanadium steels were employed. Next, as molybdenum supplies became more difficult, the former steels were largely replaced by chromium-vanadium and manganese-vanadium steels. When chromium, too, became scarce, this problem in turn was overcome by increased use of manganese steels together with higher silicon contents.

Owing to shortage of alloys the use of stainless steels in Germany was restricted to essential applications. The use of compound sheets (mild steel backing and stainless steel surface) grew considerably during the war as a result of the general shortage of alloys. Such sheets with a stainless surface on either one or both sides were produced down to a minimum total thickness of 3 mm. The advantages claimed were economy in alloys, strength combined with resistance to chemical attack, and ease of fabrication. These compound sheets were manufactured by the pack method, in which the mild steel slabs and stainless steel sheets, after the faces had been ground, were placed together, the edges being welded up. The pack was provided with a hydrogen atmosphere between the surfaces to ensure that no oxidation took place, and was then heated to rolling temperature and rolled in an ordinary plate mill. According to Krupps technicians, these compound sheets were no cheaper to produce than solid sheets of stainless steel, but were sometimes cheaper to fabricate.

High Speed Steel Substitutes

Before the war the standard 18/4/1 high speed steel was replaced by the following alloys:

C	W	Cr	V	Mo
0.80	9.50	4.50	1.50	0.50
0.85	11.00	4.50	2.50	0.50
1.40	11.50	4.50	2.50	1.00

* A Bibliographical Survey of the Development and Use of Substitute Materials for Non-Ferrous Metals and Alloy Steels in Germany, Report No. RMS-2. 1s. 6d., (by post 1s. 7½d).

In October, 1944, the following compositions were in use:

W	Cr	V	Mo	Co
7.5/8.0	3.5/4.0	1.8/2.0	0.3	nil
1.2/1.5	3.5/4.0	2.2/2.5	2.3/2.5	nil
9.0/10.0	3.5/4.0	2.5/2.7	0.3	nil
9.0/10.0	4.0/4.5	1.9/2.2	nil	2.5/3.0

The use of either nickel or molybdenum in light armour plate having been forbidden by the German Government, Roëhling used a simple chromium-silicon steel, but when the alloy situation became more critical the chromium content had to be replaced. Experiments were conducted at the Hard Armour Metal Research Association, Berlin, with the objective of producing armour plate from materials such as titanium carbide by bonding this hard substance with a ductile metal.

The most notable feature of the specifications covering alloy steels for arms was the complete absence of molybdenum, except for gun barrels and for the controlling rollers in machine gun 42. Although nickel appears in a number of specifications, it was eliminated for all gun tubes of 105 mm. and under, except in the specification for the breech end of the inner tube of the 88 mm. anti-tank gun, where 0.9/1.1 per cent was permitted. In the gun tubes above 105 mm. up to and including 210 mm., the nickel specified was also 0.9/1.1 per cent.

Diffusion Processes Developed

The Germans also did a considerable amount of work on the development of diffusion processes for the surface impregnation of ferrous articles with either aluminium or silicon. A process for surface impregnation with aluminium was used on a commercial scale, largely in order to provide increased resistance to oxidation at elevated temperatures. Much research was carried out on the surface impregnation of ferrous articles with silicon for the same purpose and also to provide increased resistance to corrosion and wear. At one works the principal articles so treated were carburising boxes, superheater and recuperator tubes, and return bends for superheaters. The boxes were said to have five times the lives of untreated ones. The quality of steel generally contained 0.10-0.20 per cent carbon, the carbon content being preferably below 0.25 per cent due to the fact that the articles treated were usually fabricated by welding.

Stainless steel of the 18/8 type was also treated to increase its resistance to furnace gases containing sulphur. Cast iron did not respond to the process. The protection afforded to articles by this treatment was reported to be satisfactory up to 950°C. Above this temperature there was a tendency to diffuse outwards through the coating and dark spots of scale appeared in the tube.

During the war years the shortage of tin had a very marked restrictive effect on German tinplate production. Although hot-dipped tinplate continued to be manufactured on a reduced scale and a new plant for electro-tinplate was installed, the main effort was directed towards the development and perfection of techniques for producing surface coatings for steel. Much information on this important field of research is contained in reports which can be inspected at TIDU.

Aluminium-Coated Iron

Substantial economies also resulted from the development of a special aluminium-coated iron. Research on this material started in 1938 as a by-product of work in progress at that period on high-grade iron as a substitute for nickel. Indications of the favourable effect of certain aluminium content on pure iron led to experiments with commercially available aluminium-coated iron sheets, used at that time for the production of such articles as cigarette boxes. Subsequently the manufacture of this material was adjusted to the special requirements of radio valve applications, for which a zinc-free aluminium was desired.

The outstanding characteristic of the material developed is that its surface changes from a normal aluminium brightness to a very dull, dark grey colour on being heated to 600°C. in a vacuum, and to a slightly lesser extent when heated in air. This surface was claimed to be an excellent black body radiator, comparable to a soot-blackened surface. Due to a roughening of the surface, gas was absorbed rather than liberated during the process of turning black. Several types of aluminium-coated sheets were developed and were extensively used for the production of radio valves.

The type most commonly used was manufactured by a cold rolling process, in which the iron and aluminium sheets, after being cleaned, were rolled together under such pressure that the consequent local

heat welded the sheets together. If the pressure and resulting deposition were too strong, the temperature would exceed 600°C. and formation of $FeAl_3$ would occur. An oxygen-containing iron and a silicon-containing aluminium were needed to raise the temperature sufficiently to make soft annealing possible for later working, since the use of a normal soft iron and unalloyed aluminium would have lowered the combining temperature to 430°C. When the material is soft annealed at 550-580°C. an aluminium oxide layer is formed, which, if especially strong, gives the impression of a varnish cover. This oxide cover gives the subsequently formed $FeAl_3$ a less dull and dark surface, and is therefore brushed off on one side by steel brushes.

Another interesting substitution in the radio valve industry was the use of thorium plated parts, Telefunken being probably the only firm in the world to make thorium powder into sheets, rod and wire. This powder was purchased from a German supplier and contained at least 97 per cent thorium metal and usually 98-99.5 per cent total thorium. The chief impurities were oxygen (as thoria), calcium, iron and soda. The iron content was generally about 1 per cent, which was regarded as the maximum permissible for the production of rod or sheet. Calcium oxide was less desirable than iron, and for consistently good results in working the metal should not exceed 0.05 per cent.

Thorium Deposition

The process employed for coating valve components was the cataphoretic deposition of thorium. The material used was a paste made from thorium powder, pure methanol, acetic acid, nitric acid and aluminium nitrate. In order to obtain a uniform coating the metal had first to be annealed in a stream of hydrogen to clean the surface. Soldered parts were annealed at 800°C. and welded parts at 1,000°C. for 10 minutes. Deposition was carried out either in a getter automatic machine or in a separate cataphoretic apparatus. The anodes were made of iron or nickel and were as nearly as possible of the same profile as the parts to be treated, which formed the cathodes in the bath. After deposition the parts were subjected to a blast of hot air in order to spread any paste adhering from the bath evenly over the surfaces and so dry the deposits. Drying had to be done carefully, especially in the case of iron parts. Care had also to be taken during the coating process that the anodes of the bath were continually kept free from adhering thorium.

The pastes used for the cataphoretic bath were inflammable and the fire risk was increased by the presence of combustible thorium powder mixed with methanol. Deposition was therefore carried out in glass containers under a tin box and each container was provided on its upper flange with a circular tube having several holes in its circumference and connected to a carbon dioxide bomb. By means of this tube the bath could immediately be enveloped in a screen of carbon dioxide should fire occur. After deposition all parts were sintered in a vacuum furnace.

Thorium Powder

Thorium powder machines very well, and parts with complicated profile can be accurately produced from rod or bar.

Other fields covered by TIDU's bibliographical survey include substitute materials for bronze and white metal bearings, substitute materials for electric cable covers and sheaths, food cans and containers developed to avoid the use of tin, substitute for tungsten in sintered carbides for tipped tools and dies, and steel cartridge cases to replace brass.

Deformation and Corrosion

continued from page 155

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Work of the Tin Research Institute

New Equipment Installed at Greenford

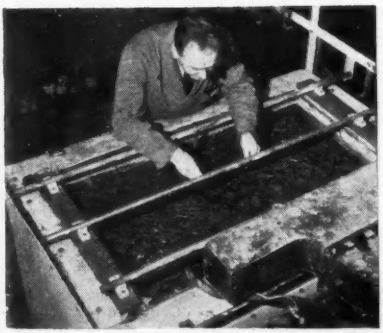
RESEARCH work at the Tin Research Institute, Greenford, Middlesex, was slightly hampered in the early part of 1950 as a number of the laboratories were out of action for some months owing to building operations.

Nevertheless progress made during last year and reviewed in the 'Report on the Work of the Tin Research Institute, 1950,' is quite satisfactory.

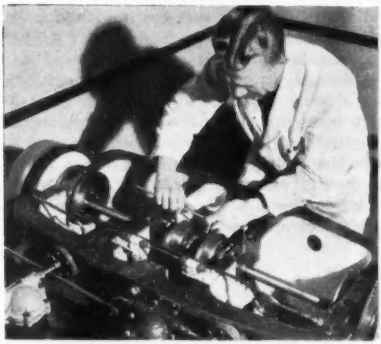
Study of the electrodeposition of tin-alloy coatings was continued. A notable achievement was the invention of a tarnish resistant finish consisting of 65 per cent tin and 35 per cent nickel, examples of which were on view when the institute's new laboratories were opened by the Duke of Gloucester on 31 May this year (THE CHEMICAL AGE, *64*, 881). Arrangements have been made for the installation of two pilot plants in England, four in Holland, and two in the U.S.A.

The laboratory has been engaged in servicing the large number of users who have installed the tin-zinc plating process during the year. This plating has also made excellent progress in America.

Adoption of this relatively new use of tin has been stimulated by the shortage of cadmium, and tin-zinc plating is already regarded as a satisfactory and relatively cheap substitute for cadmium plating. Wider uses are expected to follow as the special qualities of the coating become known.



Tin-nickel alloy plating being carried out on an industrial scale



Setting up on an Underwood bearing testing machine

Most of the heavy constructional work was completed for the installation of a circulating electrolyte cell to be used as a model for studying the effect of annealing, cleaning and plating conditions on electro-tinplate manufacture.

Studies of the thiocyanate test for tinplate were continued, and discrepancies formerly noted between results in different laboratories were traced to sampling procedure.

Five rotating-load fatigue machines designed to obtain data on the fatigue properties of bearing alloys not only at ordinary temperature but also within the range of service temperatures (100-150°C.), were installed.

Underwood bearing testing machines, awaited for some time, were set up during the year, but preliminary trial runs revealed that further modification of design was necessary. The influence of small additions of indium on the hardness, fatigue strength and microstructure of tin-base bearing alloys was investigated.

The main work on bronze was the designing and erecting in the laboratories of a machine for the semi-continuous casting of bronze bars up to 1½ in. in diameter and 10 ft. long.

Some work was carried out on the corrosion of electrodeposited zinc, cadmium, tin-zinc alloy, tin-cadmium alloy, and tin, by the

organic vapours evolved from some insulating materials in electrical apparatus. Tin was found to be outstanding in its resistance to corrosion in this way.

A method had been devised of assessing the degree of adhesion of lacquers or paints to tinplate or other surfaces, and had been incorporated in the draft of the British Standard Specification for Laboratory Performance Tests for Protective Schemes.

Available methods of chemical analysis of tin bronzes were reviewed in detail, and a selection made of the most suitable methods from the point of view of accuracy combined with reasonable speed and a minimum of manipulation. A similar study of the methods of analysis of tin ingots is now in progress.

Owing to the high degree of purity of some commercially available tin metal, particular importance is attached to the determination of 'blanks' in the chemical reagents used. For example, it was found that special precautions were necessary in the determination of sulphur, which is present in some grades of tin in amounts less than 0.001 per cent.

The use of the polarograph has been extended to the determination of tin in canned foods. A further instrumental method of analysis which had proved of value was that of amperometric titration which had been adapted to the determination of fluorides in the tin-nickel alloy plating solution.

Commendable progress has been made by the institute's technical service organisations abroad. Tin Research Institute, Inc., in the U.S.A., completed the first full calendar year of its existence with over 500 technical inquiries dealt with. Centre d'Information de l'Etain handled an increased number of inquiries from Belgium and France and has published French translations of a number of the institute's publications.

Technical service in Holland, previously provided by courtesy of the Billiton Company is now organised as Technisch Informatie Centrum voor Nederland under Baron van Voorst tot Voorst.

Chrome Ore Held Up

Six shipments of chrome ore due to be delivered to this country and the U.S. from South Africa have been cancelled, it is reported, due to a go-slow strike by South African railway artisans.

Silicone Varnishes

Overseas Research Reports

THE Technical Information and Documents Unit of the DSIR (Overseas Research Reports Department) at Lacon House, Theobalds Road, London, W.C.1, announce the receipt of microfilm reports of research carried out in America in 1947 and 1950. The subjects of the reports are the development of an air-drying silicone varnish or lacquer (four reports—1947-8), and stress-strain and elongation graphs for aluminium alloy 75S-T6 sheet (1950) (Ref. No. O.R.R.188/51.) The first report of the former contains an outline of the method of approach to the problem and a survey of the literature on silicones, with titles and authors of references. Report No. 2 contains a compatibility study of silicone resins with other organic resins, using such reinforcing resins as polystyrene, PVA, isobutyl methacrylate polymer, melamine and urea-formaldehyde.

Report No. 3 describes how an air drying silicone was formulated using ethyl cellulose and an acrylate together with various D.C. silicone resins as basic ingredients. These silicones have the unusual properties of air drying rapidly. Their brittleness was overcome by the incorporation of 2.5 per cent of dimethyl phthalate and 2.5 per cent of diethyl phthalate. The film thus formed was tough and flexible. The catalyst study was continued employing acetyl peroxide solution in dimethyl phthalate. It is recommended as a catalyst for the polymerisation of monomeric materials. The effects of the catalyst on various materials are summarised in a table.

In the final report progress made in the development of an air-dry silicone varnish or lacquer, is discussed in four sections. Section I deals with the addition of fungicides to an ethyl cellulose, acryloid, silicone system, in order to render the final film resistant to fungus growth. The test methods employed are described in section II. The compatibility data obtained throughout the investigation are summarised in section III, and section IV gives the formulations and the properties of the films after five months' indoor exposure. The formulations prepared yielded films which have properties inferior to a cured silicone system.

Polymer Breakdown

American Investigations

THE report, in microfilm form, of investigation by the National Bureau of Standards into polymer degradation in 1949 has recently come to hand at the Technical Information and Documents Unit of DSIR at Lacon House, Theobalds Road, London, W.C.1.

The investigation was undertaken to determine the mechanism of degradation of certain types of polyamides. Several methods of attack utilising the most modern tools of science were used. Films of the polyamides were exposed to heat, ultra-violet radiant energy and different atmospheric conditions. The degradation products were collected in some cases, and analysed by mass spectrometric techniques.

The unexposed and exposed specimens were examined by the following techniques to obtain information concerning the changes in chemical and physical structure of the polymer: infra-red absorption, ultra-violet absorption, viscosity of solutions, measurement of dielectric constant and dissipation factor, photomicrography, X-ray diffraction, electron microscopy, electron diffraction, and effect of organic liquids. In addition, pyrolysis studies were made, and some physical properties were determined. The results are said to show clearly that no single method gives a complete picture, but that the results from several of the methods give an insight into the degradation mechanism.

Loss of Water

Polyamide molecules are relatively unaffected by exposure to moderate temperature (60°C.). But loss of water and other volatile materials may cause changes in physical properties. The effects of exposure to ultra-violet radiant energy are more profound, including degradation of the polyamide molecule as well as loss of water and other volatile materials which act as plasticisers.

The results of the investigation show that the general course of the degradation of polyamides is as follows:

(1) The polymer molecules break at the C-N bond of the peptide group, creating smaller polymer molecules with the same unit of chemical structure. The fragments broken out are evolved as carbon dioxide, carbon monoxide, water, and hydrocarbons.

(2) The degree of crystallinity or local order changes. This includes hydrocarbon packing, dipole rearrangement, hydrogen bridging, and other types of molecular orientation and secondary bonding among the polymer molecules.

(3) The amount of strongly bound water or organic liquids changes. These materials are probably bound by hydrogen bridging to the oxygen of the peptide group or some other associated molecular complex. They act as plasticisers for the polyamides.

The investigation was made with the co-operation of 17 co-authors. A list of 116 references, and a 3-page article on 'Degradation of Plastics' by F. W. Reinhart, of the National Bureau of Standards, are included in it.

Iron and Steel Returns

INFORMATION on which the allocation of steel can be based is required by the Ministry of Supply and an Order has been made by the Minister (Mr. G. R. Strauss) calling for returns of iron and steel consumed during the first half of 1951, corresponding stocks, and estimated requirements for the following nine months.

The Order calls for two returns. Return 'A' is required if an undertaking consumed 25 tons or more of non-alloy iron and steel in the half year. A separate return is needed of all the iron and steel, including alloy iron and steel, consumed and held in stock in each of the undertaking's works and stockyards. Return 'B' is required if an undertaking consumed either five tons of alloy iron and steel or 1,000 lb. of high speed steel in the half year. A separate return is needed of all the alloy iron and steel, including high speed steel, consumed and held in stock at each of the undertaking's works and stockyards.

Returns are not required from works using iron and steel only for the main processes of iron and steel manufacture; for iron castings other than alloy iron castings; or from scrap merchants, stockholding or distributing merchants; or from warehousemen. All returns must be made in duplicate, not later than 22 August, 1951.

Allocation schemes will be introduced as soon as possible for alloy steel and for all other steel—including sheet steel and tinplate, which are already allocated.

Publications & Announcements

MESSRS. Griffin & Tatlock have just brought out two pamphlets, one on super-fractionation apparatus and one a souvenir catalogue commemorating the 125th birthday of the firm and describing their exhibits at the British Industries Exhibition. The booklet on super-fractionation apparatus describes laboratory fractionating apparatus in commercial production in this country. Two types of column are described, both developments of the Anglo-Iranian Oil Company early in the war, and the company believe it to be the most comprehensive booklet of its type to be published in this country. The types of column described are the 18 in. by 17 mm. column and the 5 ft. by 20 mm. column (length by diameter of packed section). New column packings are also described.

* * *

A USEFUL instrument for the rapid estimation of heat loss and gas content of flue gases is the Kelvin Klinkhoff Type Lossmeter with flue gas analyser. Measurement of gas content by the Flue Gas Analyser, say the company, is continuous and accurate, and can be arranged for at any required position. The instrument provides the basic information necessary, so that where the fuel content is known, the air/fuel ratio can be maintained to ensure complete and efficient combustion by the measurement of $CO + H_2$. Ambient temperature errors have been eliminated. A close indication of the losses being carried away in the flue gases can also be provided by the addition of the Lossmeter, in which the relationship of gas content to temperature of the uptake gases enables a quick visual reading of the analysis to be taken.

* * *

'OIL for Britain' an illustrated booklet just issued by the Esso Petroleum Co., Ltd., describes vividly the planning and construction of the new Esso refinery at Fawley, near Southampton, now nearing completion, while it also demonstrates the important contribution which this refinery will make to Britain's overall petroleum economy. From the striking illustration on the cover the photographs throughout the booklet provide dramatic evidence of the magnitude of the undertaking.

AMONG several recent publications issued by the Metropolitan-Vickers Electrical Company, Ltd., of Manchester, is a leaflet on vacuum pumping equipment, the type of pump described being the 'Metrovac' Oil Diffusion Pump Type O3B. This pump operates on the diffusion principle and employs Apiezon low vapour-pressure oil as the working fluid. The body of the pump and the water jacket are constructed from a non-corrodible alloy, while the oil reservoir below is made of copper to provide high heat conductivity. Other publications issued by the firm cover such subjects as hydrogen coolers for turbo-type generators, flameproof switchgear, etc. Copies may be obtained from the firm at Trafford Park, Manchester, 17.

* * *

BRITISH Drug Houses, Ltd., have recently published a new June, 1951, edition of the priced catalogue of B.D.H. Laboratory Chemicals and Testing Outfits. Owing to the exceptional conditions at the moment the company point out that the prices, although up-to-date to May, 1951, are entirely without engagement, but they propose to issue price list amendments from time to time for the convenience of purchasing departments. The catalogue contains five sections devoted to laboratory chemicals, reagents for specific purposes, amino-acids, indicators, and a miscellaneous section dealing with dyes for microscopic work, technical purposes, and food and confectionery, wetting agents, etc.

* * *

A COMPREHENSIVE pamphlet on 'Keebush'—an acid-resisting constructional material manufactured by the Kestner Evaporator and Engineering Co., Ltd.—describes the many applications of this versatile plastic. A thermo-setting plastic constructed from special phenol resin and chemically inert fillers, it possesses high mechanical properties and extremely good chemical resistance, and the company describe the many different pieces of equipment in which 'Keebush' is incorporated. These include storage tanks, laboratory type filter presses, steam injectors, etc. Several objects using the plastic were on view at the British Plastics Exhibition recently.

CHEMISTS in the textile and associated industries who want to know something about textile design and fabric structure will find instructive 'Elementary Textile Design and Fabric Structure' by John Read, F.T.I., recently revised and enlarged from its original edition in 1931. It is aimed particularly at those interested in cotton fabrics, and deals with the fundametal weaves requiring one warp and one weft. It is as much an exercise-book as a text-book on fabric structure and is obtainable from The Textile Institute.

* * *

RICHARD SUTCLIFFE, Ltd., announce the introduction of a new product—the hammock idler (Provisional Patent No. 24796/49)—which is a type of belt support developed to improve the life of conveyor belting and designed to produce a unit which has a greater efficiency than the standard three or five pulley type of idlers. It may be used anywhere along the run of conveyor installed underground or in industry.

The design enables the belt to adopt its natural curve when loaded with material. The trough is dependent upon the quantity carried and can be adjusted for materials with different specific gravities. The adjusting trough decreases the spillage and the design is such that any tendency of the load to be on one side of the belt is quickly corrected.

The rubber tube roller is designed to stand up to abrasive material and continual flexing due to variation in load. Although all impact due to heavy loads is easily absorbed, the hammock idler is not intended for heavy duty at loading points.

* * *

INCREASED shortage of steel and consequent difficulties of plant replacement emphasises the need for reducing the damage caused by corrosion in the chemical and allied industries. A step towards the effective check of corrosion is selection of chemical resistant paints for exposed iron and steelwork. One of the most effective modern protective coatings is chlorinated rubber-based paint. A new leaflet issued by Tretol, Limited, one of the first firms in England to make this type of paint, draws attention to the effectiveness of Tretol chlorinated rubber paint in industries where acids, alkalis and other chemicals are extensively used.

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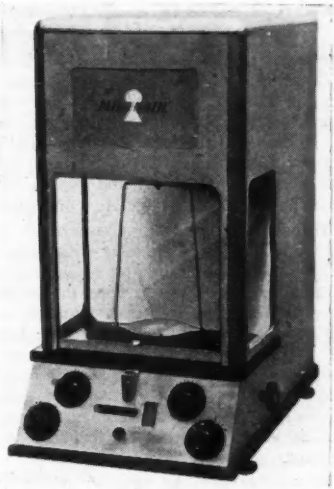

The Stanton Ultramatic Balance

A NUMBER of advanced features are incorporated in the new Ultramatic aperiodic auto-loading analytical balance shown by Stanton Instruments, Ltd., at the recent British Instrument Industries Exhibition at Olympia, London. Weight application in the new balance is instantaneous by pre-selection from a control panel placed at the base of the balances, inclined at an angle for easier manipulation from the sitting position of the operator. The 'Pre-selector' weight loading device is interlocked with the beam release mechanism so that weights cannot be moved while the beam is swinging. Through this device weights are pre-selected and they cannot therefore be thrown off through the careless turning of the selection dials.

* * *

'SULPHUR—vital rubber chemical,' is the title of an article by R. F. Reynolds, A.R.I.C., A.I.R.I., chief chemist of the Andre Rubber Co., Ltd., in the current issue of 'torque' (Vol. 1, No. 9), quarterly journal of Silentbloc, Ltd., and the Andre Rubber Co., Ltd. The author explains simply how the basic process of vulcanisation depends on sulphur and gives a formula to illustrate the make-up of a typical high performance mechanical rubber of medium hardness.

Glycol Extracts Lignin

A NEW solvent pulping process being developed by the Weyerhaeuser Timber Co., of America, using triethylene glycol, successfully extracts the lignin complex in wood, seperating it from the cellulose, and results in higher yields of strong-fibred pulp. Recovery of the lignin complex also eliminates a disposal problem and puts a former unsatisfactory end-product to good use.

The process is simple—consisting of cooking wood chips in a digester with the glycol to which small amounts of $AlCl_3$ are added as catalyst. Defibration with this added is done at atmospheric pressure and at under 250°C. Centrifuging separates the pulp from the extract, and addition of water to the lignin extract precipitates the lignin complex. Both pulp and lignin are washed countercurrently with water to remove solvent, and the dehydrated glycol is recycled to the digester.

Ninety-five per cent recovery of the glycol is the key to economic operation, and the increased cost of triethylene glycol is offset by the value of the lignin—this can be used for adhesives or as a hard board binder—and the increase in pulp production.

The lignin recovered is better quality than from other processes, since it contains only traces of carbohydrates and there is therefore no danger of condensation occurring. Pulp yield is 5 per cent higher than with other processes, it is lighter in colour, easier to bleach, and the paper made from it is stronger, as the hemi-celluloses in the wood are not hydrolysed appreciably. Also, short-fibred woods can be used for paper-making.

Recovery of Chromic Acid

THE Pfaudler Co., of Rochester, U.S.A., has installed five units for the recovery of chromic acid from electroplating bath rinse water by direct evaporation. This not only conserves chromium, but eliminates a pollution problem common to many plating works. It also cuts costs by salvaging water as well as acid. The process can be used wherever relatively pure but dilute solutions of chromic acid are formed.

Wash water with 1-6 oz. of acid per gallon is concentrated back to plate strength (30-50 oz. per gallon) in a batch still under a vacuum of 26 in. mercury, at about 125°C. Entrained particles are caught and returned to the still by a cyclone separator. Condensate is re-usable distilled water. The still—in sizes up to 3,000 gallons—is lined with resistant glass, with most other parts made from type 316 stainless steel, and has paid for itself, say the company, within six months. Previously acid was discarded at the rate of 2.5 tons per month. Effluent has now been cut from 55 ppm. to 6-7 ppm.

Physiks For All

THOSE who have watery humours or the falling sickness or wind in the stomachs and do not know what on earth to do about it should buy the latest publication of Messrs. Hutchinson & Co., without delay. This exhaustive book, readily slipped underneath the doublet, tells in detail how to cure all these things and a great many more. The growth of penicillin and streptomycin have, of course, rather put things like Cloud-berry, Fox-glove and St. John's Wort in the shade recently, but then the 'English Herbal of Physical Plants'—an abridged reproduction of the English portion of 'The Compleat Herbal of Physical Plants' published in 1694—lists a large number of diseases of which the B.M.A. has doubtless never heard. No known remedy exists to-day, we feel sure, for erosion of the guts, but flowers of Fenugreek—a herb well-known to inveterate curry-makers—mixed with the juice of Smallage and two pugils of rye bran are prescribed as an excellent cure for this and other equally noxious diseases. The publication we refer to has, it is true, been out of print for a considerable number of years, but sceptics allergic to medicine bottles and the like will not find anything to grumble about on this count. One short word of caution, as uttered by Mr. Pechey himself—'it is very hazardous in many cases to administer physik without the advice of physician.' You have been warned. Price 3s. 6d.

New Directors

Babcock & Wilcox, Ltd., announce that SIR FREDERICK LEITH-ROSS and M. JEAN LOUIS have been elected directors. Sir Frederick, who after long service at the Treasury, held the post of economic adviser to the Government from 1932-1946, was recently appointed to the board of the National Provincial Bank. M. Louis is president of the Société Francaise des Constructions, Babcock & Wilcox, Paris.

HOME

Move to New Factory

A wide range of indicating, recording and controlling pyrometers is now being made for the chemical, metallurgical, rubber and other processing industries by the Industrial Pyrometer Co., Ltd. Such satisfactory progress has been made since the company's formation five years ago, that to satisfy increasing demands it will move into a new 5,000 sq. ft. factory at Gooch Street, Birmingham, towards the end of next month. Success is largely attributed to progressive design in conjunction with standardisation of parts.

Drainage of Trade Premises Committee

The first meeting of the Committee appointed by the Secretary of State for Scotland to consider the drainage of trade premises was held on 23 July, when it was decided to meet industrial and other interests concerned. The terms of reference of the Committee are 'to consider on what conditions and subject to what financial arrangements, industry should be entitled to discharge trade waste waters and effluents into local authority sewerage systems; and to make recommendations.' Anyone desiring to submit evidence should communicate with the secretary, Department of Health for Scotland, St. Andrew's House, Edinburgh 1, before 30 September, 1951.

Changes in Export Control

Alterations in export licensing regulations affecting a number of chemicals are announced by the Board of Trade as from 1 August. From that date licences will be required for the export to any destination of indium and its compounds, phthalic acid esters, and *p*-chloronitrobenzene.

Licences will be required for the export, to any country other than the Commonwealth (excluding Hong Kong), Irish Republic, and U.S.A., of boron carbide, certain carbon powders, aluminium and its alloys in additional forms, calcium metal, certain types of chemical process vessels, specified pumps and parts, chucks, expanding arbors and collets, dynamometers, certain types of furnaces, and certain synthetic organic chemicals of the kinds used in flotation.

Sodium Nitrate Price

The price of Chilean nitrate of soda (industrial), crystal and granulated 97-98 per cent for six-ton lots delivered nearest station has been raised from £23 to £29 15s. per ton. This price will remain in force for delivery until 30 November, it is announced by the Nitrate Corporation of Chile, Ltd.

Paraffin Wax Prices

Revised prices for paraffin wax as from 16 July are announced by Shell-Mex and B.P., Ltd. Prices per ton ex-store/works to consumers operative are: Minimum one ton lots, £76 5s.; smaller quantities, £77.

Price Increase of Shell Acetone

Shell Chemicals, Ltd., announce that the price of Shell acetone was raised by £25 per ton as from Monday, 23 July.

American Resins Available to U.K.

'Epicote' resins, condensation products of epichlorhydrin and diphenylolpropane known in America as the 'Epon' resins, are now being handled in the U.K. exclusively by Shell Chemicals, Ltd. Four surface coating grades are at present available in limited quantities for development work, designated as Epicote 1001, 1004, 1007 and 1009. Surface coatings based on these resins are characterised, it is claimed, by excellent flexibility and adhesion coupled with unusual hardness and resistance.

Scarce Materials

Sir Graham Cunningham, chairman and managing director of the Triplex Safety Glass Co., Ltd., who recently toured the United States as head of a team of British industrialists to study the conservation of scarce raw materials, has stated that British and U.S. industrialists have pooled ideas on saving scarce materials. He said: 'I hope one of the most useful results of our trip may be that United States' industrialists will come to Britain; Britain for her part may send teams from the United Kingdom to pinpoint various aspects of the conservation programme'. The visit was sponsored by the Anglo-American Council on Productivity.

OVERSEAS

Norwegian Aluminium Works

A contract for the construction of a new aluminium works at Sunndalsoera on the west coast of Norway was signed on 25 July by the acting Norwegian Minister of Industry on behalf of his Government and Mr. John Gross, leader of the Economic Co-operation Administration mission to Norway. ECA is to provide a loan of $24 million (approximately £8.5 million), which is to be repaid by deliveries of 7,800 tons of 99.5 per cent pure aluminium a year over a 10-year period beginning in 1955. The works will be at the Aura waterfalls where a water power plant is already being built.

Wax From Lignite

Experiments on the extraction of wax from lignite in Saskatchewan now seems possible. Reporting results to the Canadian Chemical Conference in Winnipeg recently, a research team from the University of Saskatchewan stated that a 4 per cent yield was obtained with a solvent consisting of a ternary azeotrope of benzene, ethyl alcohol and water. Preliminary acid treatment of the lignite doubled the yield. The amount of lignite recoverable in this part of Canada is estimated at as much as 6,500,000,000 to 12,000,000,000 tons, in seams over three feet thick with no more than 500 ft. of covering. The wax so far recovered seems in preliminary tests to be similar to montan wax extracted from German brown coals. Satisfactory recovery of wax may change the whole lignite economic outlook. For a new lignum extraction process, *see* page 164.

Norwegians Tax Exports

From 1 August the Norwegian authorities will extend the system of export taxes, now imposed on paper and pulp, to cover sulphur, pyrites and copper. For sulphur the tax will be £7 10s. a ton, for pyrites 5s. a ton, and for copper £15 a ton. The revenue from the export taxes will be used by the Price Directorate to reduce the price in Norway of various imported materials. Norway last year exported 76,162 tons of sulphur, 389,000 tons of pyrites, and 11,000 tons of raw copper and copper waste.

No More Acrolein

Shell Chemicals, it is reported, has discontinued pilot plant production of acrolein in America, due to lower market demand than expected. The potential market for this intermediate is estimated to be only 450 tons a year, and this can readily be filled by other companies which make acrolein as intermediates in their own processes. Shell is concentrating on its 50 per cent expansion of glycerol capacity, its new benzene hydroforming plant at Houston, and the introduction of dodecyl benzene, an intermediate for detergents, at Wood River, Illinois.

Search for Inventors

Two months ago the Sinclair Refining Company of America announced that it would throw open its research laboratories to any inventors with a new petroleum product or application. Now the United Dye & Chemical Corporation has entered the field and is offering its facilities and experience to companies and individuals with chemical problems or practical ideas, with the object of furthering chemical product research and development. The company will sift ideas and develop suitable ones in co-operation with the orginator. The main line of interest to the company lies with organic chemistry—specifically vegetable and synthetic dyes and pigments. A subsidiary company makes drugs.

Canada's Largest Cracker

Construction work has started, announced the W. Kellogg Co., on Canada's largest catalytic cracker at Sarnia, Ontario. This cracker—its capacity is rated at 25,000 barrels per day—is part of an overall modernisation programme being undertaken by Imperial Oil, Ltd. A subsidiary of Kellogg's—Canadian Kellogg Co., Ltd.—is also scheduled to build a 46,500 barrels-per-day, two-stage vacuum and atmospheric distillation unit, as well as a light ends recovery system. The distillation unit capacity is believed to be the largest in Canada. When the equipment is on stream, the refinery's capacity will be increased by almost 30 per cent, or to 71,000 barrels daily, a remarkable expansion.

The Chemist's Bookshelf

CHEMISTRY OF ORGANIC COMPOUNDS. Carl R. Noller. W. B. Saunders Company, Philadelphia and London. 1951. Pp. 885. 35s.

There are three possible forms in which an elementary textbook upon organic chemistry can be produced. These may be described as the historical, the theoretical and the practical. The history of organic chemistry has followed such a confused and tortuous course that few authors have chosen the first form and none succeeded in making it palatable to the student. The second form involves the treatment of the material from the standpoint of molecular and electronic structure and has the supreme virtue of clarity, although some of this clarity is superimposed rather than implicit. The third form should prepare the student for creative work in the laboratory, it should acquaint him with the chief sources of basic chemicals and eliminate the idea that the best way of obtaining a specific chemical compound is to pay somebody else to make it for you. It is unfortunate that few examples of the third form achieve this end.

Most authors including Professor Noller attempt a compromise between the third and second forms, although some cannot refrain from adding a little alchemy for good measure. The scope of the present volume is quite wide, and in addition to the usual groundwork, there are chapters upon specific topics such as dyes, oils, fats and waxes, terpenes, heterocyclics, rubbers, organometallics, alkaloids, and steroids, but not vitamins, hormones or subjects of biochemical interest.

The most unusual innovation is a section dealing with the pronunciation and spelling of the chemical language. This is based upon a report of the American Chemical Society published in the News Edition of the journal 'Industrial and Engineering Chemistry'. The author's arrangement of the information is questionable; as he points out in his preface, no compound is used in the preparation or reactions unless its structure has been discussed previously. This approach, while leading to conciseness in some cases, inevitably leads to the spreading of related information in others.

In the chapter upon dyes the author makes the surprising statement that the dyes that have proved most useful (photographically) are the cyanine dyes derived from quinoline derivatives. In fact almost no quinoline dyes are used to-day in photographic manufacture, the cyanines being derived from other heterocyclics.

Professor Noller does not mention in his discussion of aryl mercury compounds the readiness with which the electro-negative radical may be exchanged for a hydroxyl or other radicle, and his contention that mercurials of high molecular weight do not penetrate cellular tissue has recently been disproved by the appearance of phenyl mercury derivatives of dinaphthyl methane sulphonic acids which do have this property and are substantive to skin. In other ways, however, and particularly as regards price and excellence of production this book has much to recommend it to the student. —J.R.M.

BASIC REFRACTORIES: THEIR CHEMISTRY AND THEIR PERFORMANCE. J. R. Rait. London. Published for *Iron and Steel* by Iliffe & Sons, Ltd. 1950. Pp. 408, Figs, 110. 60s.

This is a comprehensive account of basic refractories—dolomite, magnesite, chrome-magnesite and forsterite—by a chemist who is an active investigator in the field.

Since by far the greater proportion of steel is nowadays produced from basic furnaces, the subject is of vital importance. Prior to the last war, however, the tendency was to import basic refractories which experience had proved satisfactory, rather than to make use of synthetic materials produced from raw materials available at home. Very little fundamental investigation of the nature and functioning of basic refractories had been carried out, and such investigation was rendered highly necessary by the shortage of

shipping space during and since the war.

The present book can be regarded as divisible into three broad sections. In the first, there is a review of knowledge of the fundamental physical chemistry of basic refractories available up to the war. This is essentially the knowledge of certain parts of the phase relations of the five-component system CaO-MgO-SiO_2-Al_2O_3-Fe_2O_3.

This review showed clearly that a considerable part of the results needed to complete the field had not been determined. Using classical methods it would have been an exceedingly lengthy and formidable task to supply the missing information. However, by more modern and direct methods the author and his collaborators have filled the gaps. A detailed account of the investigations carried out to this end forms the second part of the book.

The third major section examines the constitutions of commercial basic refractories, and makes an attempt to correlate these constitutions with the properties of the materials and with their behaviour in service. Chrome ores, also of importance in this field, have been included in the investigation.

It is clear from an examination of the material presented in the last section that a considerable body of research still remains to be done. There are still types of failure, for example, which can be avoided empirically, but for which no adequate explanation can be presented. However, here is a record of a first-rate piece of work, well written, fully illustrated by diagrams and photographs, and documented by a most extensive set of tabular data. There is a full bibliography. The book is well-produced, and will undoubtedly be of much value to all who have an interest, either fundamental or applied, in refractory technology.—W.

MATERIALS OF CONSTRUCTION FOR CHEMICAL PROCESS INDUSTRIES. By James A. Lee. McGraw-Hill Book Company, Inc., New York, Toronto and London. 1950. Pp. ix + 468. $6.50.

This book deals with materials of construction found most satisfactory in the processes involved in the manufacture, treatment and handling of some three hundred products and groups, described as chemicals, though most people would object to soup being classified as a chemical product. The writer clearly intended it as a reference book. Hence all 'chemicals' are given in alphabetical order. Thus apricots are next to arsenic, olives are followed by oxalic acid and butter close behind bleaching powder. This alphabetical classification suffers from the great disadvantage that closely related materials are dealt with under different headings. Butter, peanut butter and margarine should have been treated under one heading, lemon juice and citric acid could have been combined making the description more unified and compact. The author could still have retained his dictionary plan by maintaining all headings he intended and attaching to them page references. It was wise to give occasionally more than one process for each material. It makes the book more readable and less of a dry reference book.

Omissions in such a book are bound to be many. This is unavoidable but one is almost general and could at least have been minimised. I refer to the union of the lining of various stills, tanks and autoclaves to the body of the apparatus and the sealing of the joints which is only second in importance to the linings themselves. In dealing with processes the author has taken the easiest course by quoting wherever possible German processes investigated by Allied experts under the Armistice agreement. This is apt to give the impression that the Germans invented the processes described. At least one of these has never gone past the laboratory stage.

There are a few errors, some of them very undesirable. For example, a surface coating of concrete tanks used for storing and treatment of sauerkraut with zinc fluosilicate as recommended is most dangerous, even if it does 'protect the taste'. Sodium silicate is good enough.

There is another important fault which it shares with some notable American publications. It gives seventeen pages, each with thirty to thirty-five titles of materials and the names and addresses of their American makers. Only two or three suggest British associations. Among some eighty titles on stainless steel there is only one beginning with the name 'Firth' which reminds the knowledgeable reader that stainless steel is a British invention. Putting it bluntly, the seventeen pages form an American trade catalogue.

In spite of these shortcomings, the volume is a compilation of great value to the chemical engineer who by studying the numerous references, if required, should be able to fill in the missing links.—S.P.S.

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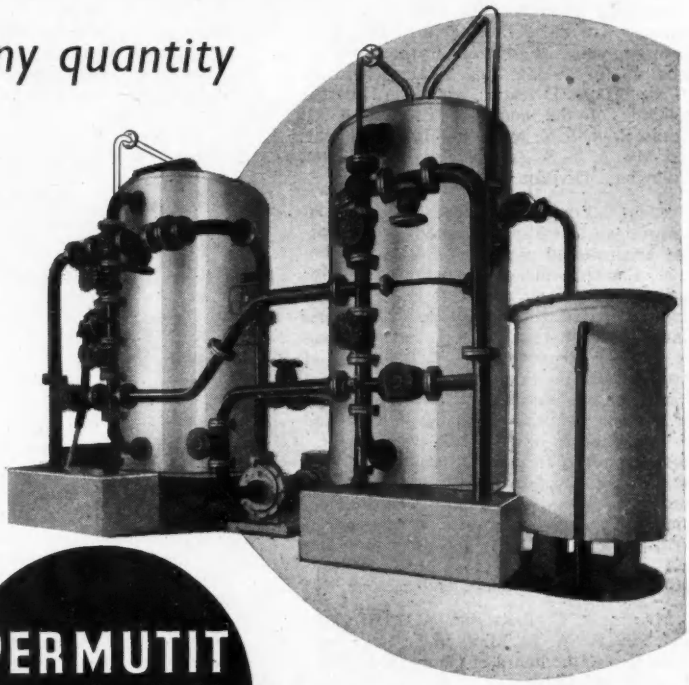

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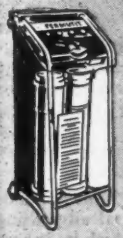

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PERSONAL

Imperial Chemical Industries, Ltd., announce that the following directors have been appointed as additions to the board, as from 26 July;—MR. P. C. ALLEN, chairman of the Plastics Division: MR. E. A. BINGEN, solicitor of the company; CAPTAIN R. C. TODHUNTER, R.N. (rtd.), Purchases Controller; MR. A. T. S. ZEALLEY, chairman of the Billingham Division.

V. G. BARTRAM, of Montreal, president of Shawinigan Chemicals, Limited, of Canada, has been elected president of B.A.-Shawinigan, Limited, the newly-organised petrochemical company owned jointly by The British American Oil Co., Ltd., and Shawinigan Chemicals, Ltd. Vice-president of the new company is M. S. BERINGER, of Toronto, British American's vice-president in charge of manufacturing. Other directors of the new company are DR. R. S. JANE and P. W. WRIGHT, of Montreal, vice-president and secretary-treasurer respectively of Shawinigan Chemicals, and H. T. O'NEILL and R. E. IRWIN, of Toronto, vice-president (finance) and chief chemist, respectively, of British American Oil. The new plant's output is expected to make Canada self-sufficient for both phenol and acetone.

MR. L. A. C. BARTLETT, A.M.I.Mech.E., and MR. W. A. H. MAY, M.C., have been appointed to the board of George Kent, Ltd., London and Luton.

Mr. Bartlett has been with George Kent, Ltd., for 25 years, entering the firm as an apprentice. After service in most of the departments of the firm he was, in 1939, placed in charge of research on automatic control systems. During the war he was responsible for the handling of Admiralty contracts and was appointed Luton sales manager in 1945. Several months ago he was made commercial manager.

Mr. May, who is a great-grandson of the founder of the firm, joined George Kent, Ltd., in August, 1938, as personnel manager. He served for nearly seven years in the Royal Engineers during the war, reaching the rank of major and winning the Military Cross. He returned to the firm in 1946 and is now administration manager.

MR. GLANVILL BENN, chairman of Benn Brothers, Ltd., proprietors of THE CHEMICAL AGE, has been appointed a trustee of the National Advertising Benevolent Society, to fill the vacancy caused by the death of Sir William Crawford. The other trustees are LORD CAMROSE and LORD MACKINTOSH OF HALIFAX.

Six new Fellows and 15 new Associates were elected to the Institute of Physics on 19 July, as follows:—

Fellows: I. I. BERENBLUT, J. B. BIRKS, R. L. BROWN, H. W. FRENCH, J. H. FEWKES, W. R. LANG (Australia).

Associates: D. K. BEWLEY, D. S. BOX, P. R. BRETT (Australia), J. W. CHRISTIAN, H. J. CULL, T. A. HEDDLE, J. HOLDEN, G. F. LEWIN, D. J. R. MARTIN, E. N. MARTIN, K. SWAMINATHAN (India), D. F. URQUHART (Australia), A. F. WATSON, K. WESTERMAN, E. WILLIAMS. In addition 19 Graduates, nine subscribers and five Students were elected.

The London and Home Counties Branch of The British Association of Industrial Editors was addressed by MR. HOWARD A. MARPLE, director of advertising for the Monsanto Chemical Company, St. Louis, Missouri, at Chez Auguste Restaurant, London, on 17 July. His subject was 'The Way of an American Editor' and he described the evolution of American industrial journalism and its close connection with public relations.

Mr. Marple is one of America's most outstanding industrial editors who, when he became editor of *Monsanto Magazine* in 1938, rejuvenated the American house magazine movement. Under his editorship the magazine received over a dozen prizes for editorial excellence, including the highest award of the International Council of Industrial Editors, of which he was one of the founders and a past president.

His success in this field led to his appointment to the head of the central advertising department of Monsanto, of which he is now a director.

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Commercial Intelligence

The following are taken from the printed reports, but we cannot be responsible for errors that may occur.

Mortgages and Charges

(Note.—The Companies Consolidation Act of 1908 provides that every Mortgage or Charge, as described herein, shall be registered within 21 days after its creation, otherwise it shall be void against the liquidator and any creditor. The Act also provides that every company shall, in making its Annual Summary, specify the total amount of debt due from the company in respect of all Mortgages or Charges. The following Mortgages or Charges have been so registered. In each case the total debt, as specified in the last available Annual Summary, is also given—marked with an *—followed by the date of the Summary, but such total may have been reduced.)

MARCHON PRODUCTS, LTD., London, W.C., chemical merchants, etc. (M., 4/8/51). 21 May, deed supplemental to a trust deed dated 19 August, 1949, varying terms of trust deed; charged on properties specified in deed. *£300,000. 29 June, 1950.

MERTHYR TYDFIL CERAMICS, LTD., Cardiff. (M., 4/8/51). 31 May, £40,000 (not ex.) debenture, to H.M. Treasury Solicitor; charged on specified property and a general charge. *£110,000. 18 December, 1950.

MITCHELL & HARDY (PLASTICS), LTD., London. (M., 4/8/51). 31 May, mortgage, to Halifax Building Society securing £3,000 and further advances; charged on land and factory buildings at London Road, Thorley (Herts.). *——. 16 August, 1949.

W. H. SANDERS (ELECTRONICS), LTD., Stevenage. (M., 4/8/51). 4 June, £3,500 debenture, to I. C. M. Worsfold, Richmond (Surrey); general charge. *£7,729. 25 December, 1950.

Increases of Capital

The following increases of capital have been announced:—EVANS ELECTROSELENIUM, LTD., from £3,000 to £10,000; BELLAMYS DISPENSING CHEMISTS, LTD., from £5,000 to £17,000.

Company News

Murex, Ltd.

Preliminary statement for the year ended 30 April shows that group profits of Murex, Ltd. before tax but after all other charges, have increased by £917,000 to £1,649,000. Final dividend on the £2 million ordinary stock will be raised from 6 per cent to 7½ per cent, making a total of 12½ per cent less tax. The meeting will be held on 19 September.

Benn Brothers, Ltd.

The directors of Benn Brothers, Ltd., recommend the payment of the following final dividends less tax for the year ended 30 June, 1951:—Three per cent on preference shares, which with the interim dividend of three per cent paid in February makes 6 per cent for the year; 20 per cent (same) on ordinary shares, as increased by the issue of bonus shares in December, 1950, which with the interim dividend of 5 per cent paid in February makes 25 per cent for the year; 5s. per share on the deferred shares (same).

Market Reports

LONDON.—There has been no slackening of interest on the chemicals market during the past week, and the demand generally is sustained particularly on export account. Movement of supplies to the chief home consuming industries has been somewhat curtailed owing to holiday conditions, but the effect has been less noticeable than is usual for the period. Prices remain strong in all sections with a tendency towards higher levels. Brisk trading conditions continue in the market for coal tar products and buyers are finding it exceedingly difficult to cover their requirements. The pyridines, phenol and the cresylic acids are in persistant demand and offers of the naphthalenes are scarce.

MANCHESTER.—There has been little change in conditions on the chemical market during the past week. Seasonal effect on the demand has been less in evidence than usual, delivery specifications from the textile and other leading outlets covering substantial aggregate quantities, especially in the alkali products. Prices in all sections are on a firm basis. Active conditions are again reported for the tar products, with makers well sold forward in most sections.

GLASGOW.—The overall position is practically unchanged, but with the number of orders on hand awaiting delivery, manufacturers can certainly look forward to a very brisk period during the next two or three weeks; the position generally is healthy. Export continues brisk with a steady demand, not all of which can be met, but the position is quite satisfactory.

1952 BIF on a Large Scale

WITH one-third of available space in the London sections already sold and the rate of bookings at Birmingham slightly up on last year, the organisers of the 1952 British Industries Fair, to be held from 5 to 16 May, are confident that the sixth Fair since the war will compare with the best in the postwar period.

There has been a tendency in many quarters to assume that the 1951 BIF in Festival Year would represent the Fair's peak achievement, after which a sharp decline in size, representation and influence could be expected. The rate at which demands for space are coming in, and the variety of industries involved, does not support this theory. The organisers, for their part, are again extending and improving promotion plans for the Fair at home and abroad, and it is hoped that attendance of overseas buyers at the 1952 BIF will be well up to the average at each Fair since 1947.

In London, sale of the space available at Earls Court and Olympia, is a marked improvement on the position at the same period last year. Intending exhibitors have been advised that if applications for space are not received by 25 August, they may have to be placed on waiting lists.

Application for the Castle Bromwich, Birmingham (heavier engineering) section are at a slightly higher rate than the peak level of last year.

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SITUATIONS VACANT

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APPLICATIONS are invited by the Division of Atomic Energy (Production) for the following appointments in the Research and Development Branch, Risley, Nr. Warrington, Lancs.:

POST A.—PRINCIPAL METALLURGIST to take charge of a laboratory engaged on research into powder metallurgical techniques of rare metals. Responsible post graduate or research experience in powder metallurgy is essential. Candidates should be at least thirty-one years of age.

POST B.—SENIOR METALLURGISTS to supervise groups engaged on powder metallurgical research. Candidates should be at least twenty-six years of age and have had a minimum of three years' research experience in powder metallurgy.

POST C.—METALLURGISTS to undertake research work on the powder metallurgy of rare metals. Applications will be considered from candidates expecting to obtain Degrees this year.

Candidates must have either first or second class Honours Degree in physics, metallurgy, chemistry, or physical chemistry, or equivalent qualification.

Salary will be assessed according to qualifications and experience within the ranges. Post A, £960-£1,295 p.a.; Post B, £720-£910 p.a.; and Post C, £380-£620 p.a. Rates for women are somewhat lower. The posts will carry F.S.S.U. benefits. Houses will be available within a reasonable period for the successful candidates, if married. Applications to **Ministry of Supply, D. At. En. (P), Risley, nr. Warrington, Lancs.,** stating post applied for.

RS. 7630-25-SMP.

ASSAYER required for position on Northern Nigerian tinfields, must be well qualified in assaying of lead, zinc and silver ores as well as tin and columbite ores. Salary, £75 per month with cost of living allowance of £15 per month if married, £10 if single. Two year tours with four months leave on full pay on completion. Passage, housing, furniture, lighting supplied. Provident Fund and Pension Scheme in being. **Apply in writing to, A.O. Nigeria Limited, 55-61, Moorgate, London, E.C.2.**

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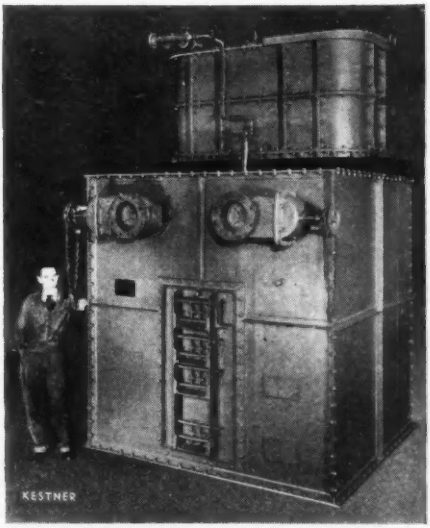

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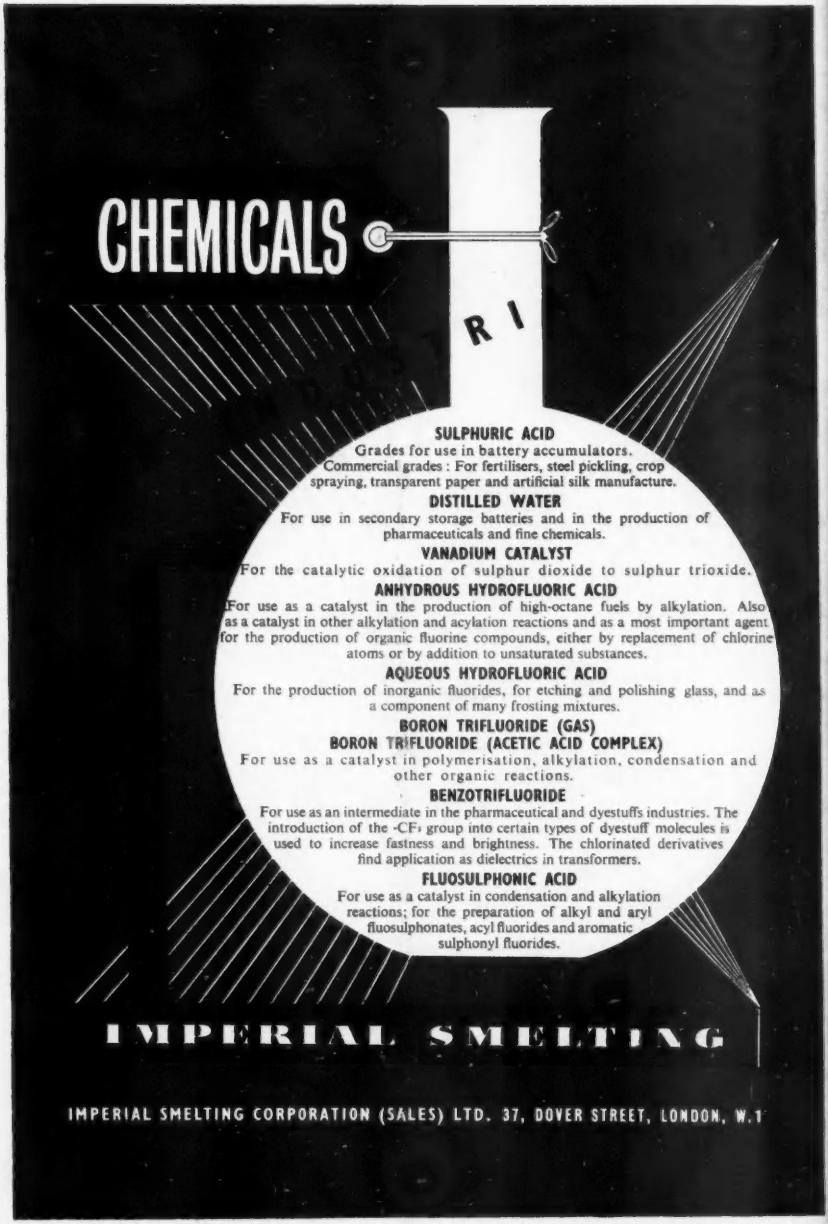
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